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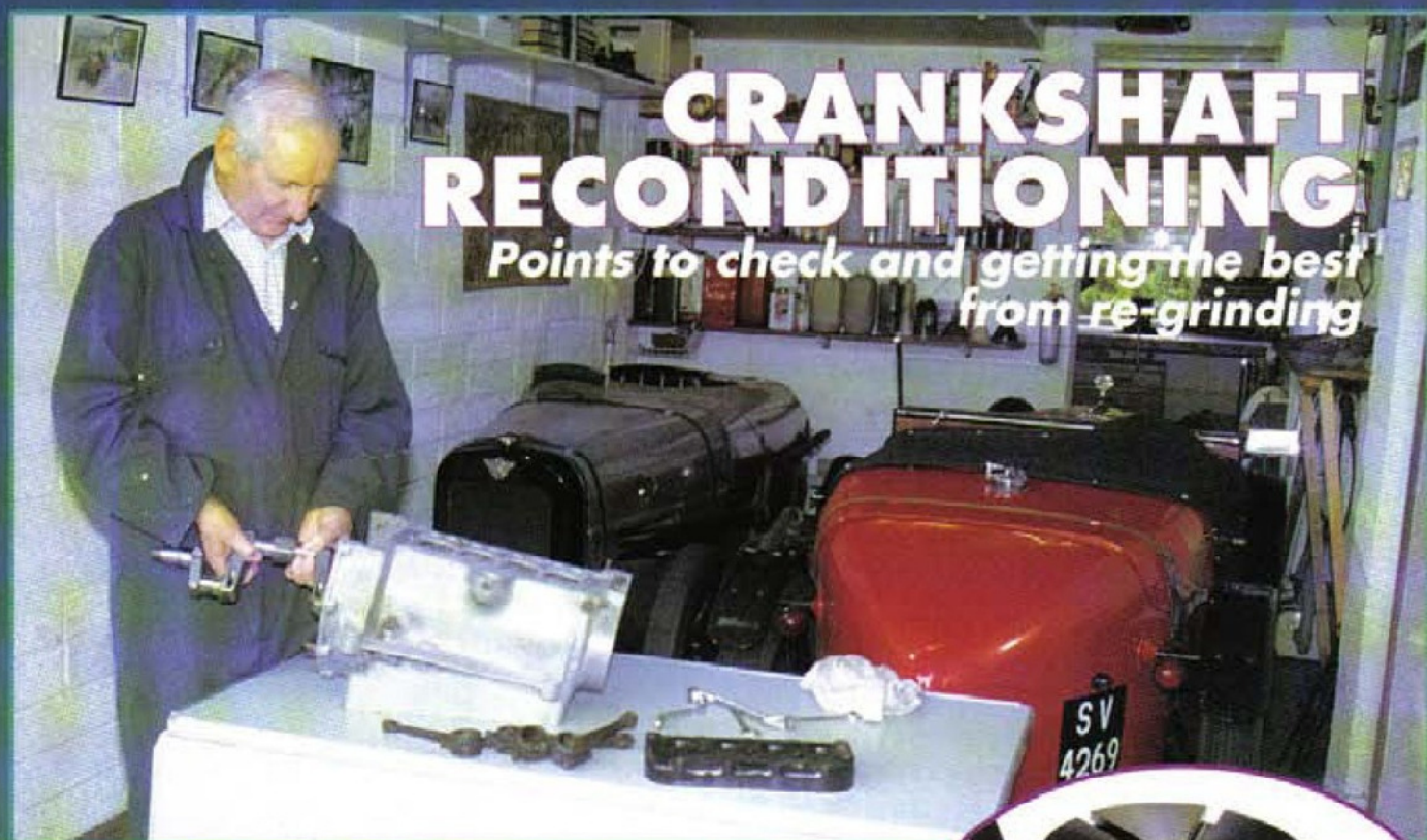
MODEL ENGINEERS'

WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

CRANKSHAFT RECONDITIONING

Points to check and getting the best from re-grinding



GEARED ROTARY TABLE

Designed for the Unimat 3

HAND TURNING

A chance to learn new skills



ENAMELLING

For enhancement, protection or art metalwork

SIMPLE TOOLS

Apprentice pieces for the newcomer

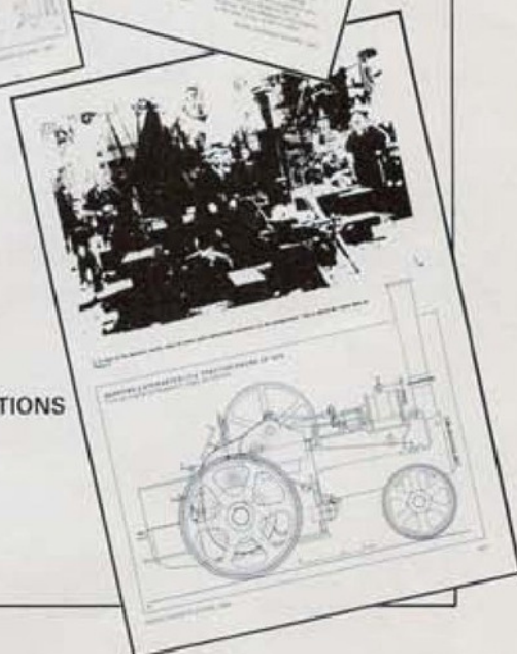
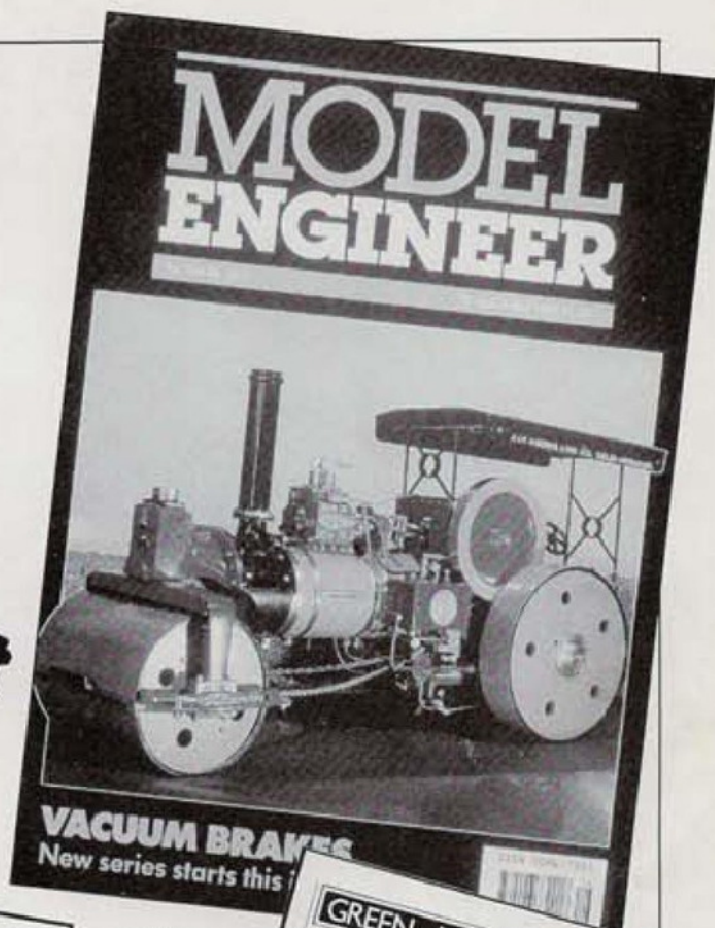


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**SOMETHING
TO LOOK
FORWARD
TO...**
...every fortnight



There's something to anticipate twice every month in fascinating Model Engineer magazine! Whether your interests lie in live steam locomotive models, traction engines, internal combustion motors or stationary engines, world famous M.E. will inspire, instruct, advise and encourage. Model Engineer is published on the first and third Fridays each month and costs just £1.40 from all good newsagents; alternatively, you may care to ensure your regular copies through an annual subscription – a mere £33.60 for UK readers (overseas rates and airmail details on request).

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Issue No.

30

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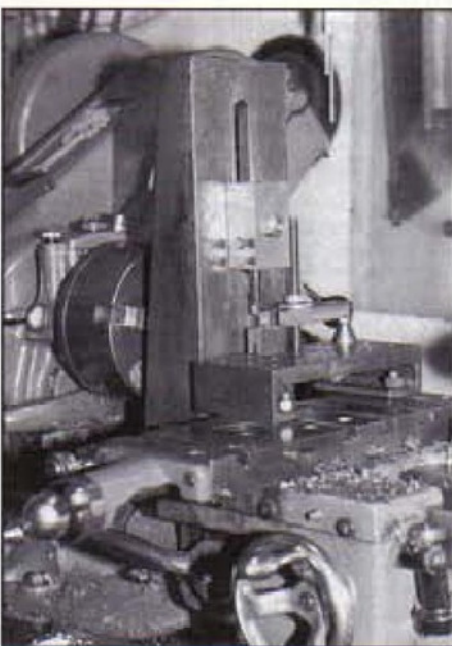
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Not a safe, it is actually an oven used for firing the enamelling on small objects. This is a technique which can be used for a variety of purposes - seemingly limited by your creativity. Read all about it starting on page 32.

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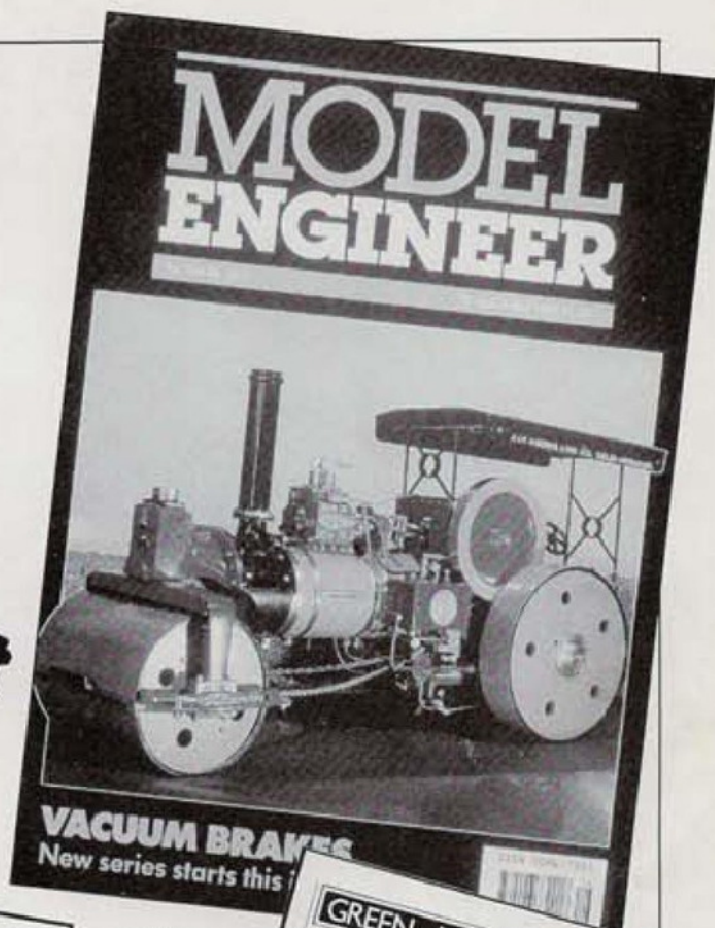
MODELLER ON THE COVER

Hardly a modeller, more of an expert restorer of vintage Austin 7's, Brian Owens is seen handling a crankshaft from one of his engines, he also restored or rebuilt the cars in the background

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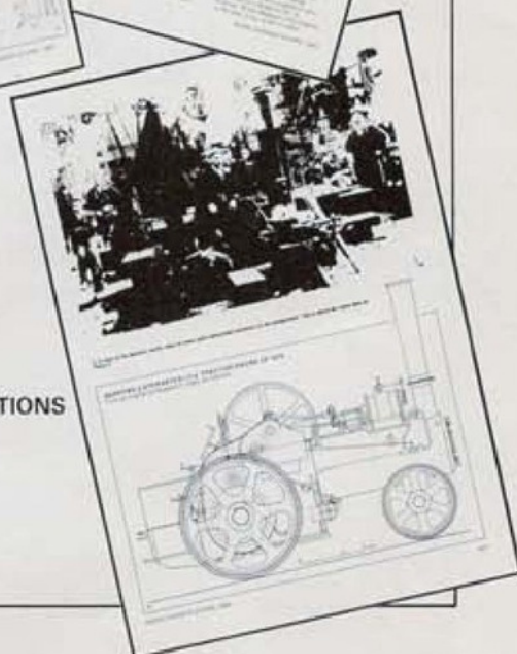
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Geoff Hoggard

ON THE EDITOR'S BENCH

May I firstly say Thank You to all those readers who have sent kind words and messages of encouragement following the publication of my first issue of *MEW*. I have to admit that the learning curve was very steep and that the task was possible only because I received much help and advice from a number of people, particularly the team at Hemel Hempstead. The team of contributors built up by my predecessors is also continuing to be very supportive, as are the members of the family who are having to adjust to my very different work regime.

Secondly, it is also Thank You to the couple of people who have taken the time to write letters of criticism, because in both cases the points they made were valid and both were constructive. I too was dissatisfied with a number of aspects and I need to work on them. One specific area is that of the *Quick Tips*. Once again we have managed to duplicate a couple of these within the one issue. It requires better co-ordination between those of us in the Editorial and Design functions, particularly in the last few days of the cycle.

As I was aware when I agreed to take this post, the success of a magazine of this sort depends totally upon the contributors. No matter how much effort the editorial team puts in, if there is not a steady supply of interesting, technically sound articles, the whole thing will fail. I could spend all my time in the workshop producing projects, then photographing them and writing them up, but within a matter of months it would become totally boring. My message is, therefore, to previous contributors - please keep up the good work, and to anyone who feels like having a go - please don't hesitate to contact me with your ideas.

Probably the best way is to write to me at Nexus House, giving me an outline of the project you have in mind and a contact telephone number, so that we could discuss your ideas before you put too much effort into an article which perhaps covers the same ground as one that I have just received. Looking back over the articles on file which I inherited and those which I have received since, it is interesting to see how articles on given topics seem to come in waves. I guess that something in a published article or in Scribe a Line sparks off the same idea

with a number of people at the same time, encouraging them to put pen to paper.

Harold Hall, my predecessor, put together some guidance notes for potential authors. I am updating these because the technology is always changing and, hopefully, making the task easier. In essence, all I need is:-

1. A clearly typed script (single spaced these days)
2. Simple, clear drawings, if possible (but not essential) in 3rd. angle projection with metric dimensioning.
3. Photos of the finished article and interesting stages of manufacture. These need to be sharply focused and with a good colour balance.

Dot matrix printers are to be avoided because the scanners currently used to read material into the processing systems seem to be completely confused by the gaps between the dots, and if you can send the words on a disk, the job is really simplified, but do check with me first to ensure that our systems are compatible.

When considering the types of article which should make up the content of this magazine, I am of course influenced by the views expressed in such things as the Reader Survey and in your letters, which I am always delighted to receive. The contrasting views expressed could not be more extreme. On the one hand are those from the beginners, pleading for guidance on how to go about the most basic of tasks, while an interesting letter from a reader in Canada contains an exhortation that we should deal with much more advanced techniques and states "the magazine has fallen to such a puerile stage that a junior in technical studies school would be bored". Future editorial efforts will, of course, be directed to satisfying the requirements of both ends of the spectrum, plus all those in between!

One of the difficulties I see is that the technology level of most of our home workshops is stuck in a bit of a time warp. As Don Unwin's historical series of articles illustrates, most of the processes we employ were fully developed by about 1860. The only real advance since then has been the application of electricity, which has enabled us to get rid of the treadle and to find new ways of sticking metal together. This means that the machines we use and the things that can

be done with them are well understood and have been very fully documented. Consequently, it is very difficult to find an accessory or attachment that hasn't been described many times before in some publication or another (usually *Model Engineer*), and repetition is inevitable. If we look to the industrial engineering industry for inspiration, we find that the rate of divergence between the technologies we can handle at home and those used commercially is higher than it has ever been. Forays into the amateur use of electrical discharge machining, pioneered by the late Roy Amsbury and the late Derek Williams do not seem to have flourished except in the occasional removal of a broken tap. I have heard of the manufacture of a set of miniature locomotive connecting rods by the wire cutting technique, but I suspect that job was the ubiquitous 'foreigner'. Electrochemical machining and laser cutting and drilling are well beyond most of us and explosive forming could cause a degree of panic among the neighbours (one pal used to get some sideways looks when he stoked up his backyard furnace to melt cast iron!).

Even in the field of traditional metal chip removal techniques, commercial concerns are having to advance if they are to reduce their unit costs and stay viable. Only the other evening I heard tell of an acquaintance who lives in one of the more remote Cotswold villages, who went into his 'local' one Friday lunchtime, to find the proprietor of the nearby two-man jobbing engineering shop enjoying a pub lunch. "What's this, then. Business a bit slack?" "Just the opposite" came the reply, "I've recently installed four CNC lathes and they're all up and running, and Jim can look after the lot, so I thought that I would have a bite to eat, for a change". In future years, the amateur looking for redundant commercial equipment for his workshop is going to have to consider an entirely new range of machines.

All this suggests that finding fresh material for the pages of this magazine is going to become totally impossible or completely fascinating. What do you think? Please tell me.

A Model Engineering Summer School

I have just returned from the annual visit to the Modellers' Holiday at Primrose Valley at Filey in Yorkshire, where Stan Bray, Roger Nicholls and I have been up to our usual antics in the workshop (now christened the MEW workshop), to find a brochure for another engineering related activity holiday. This is the Loughborough College Model Engineering Summer School, where, under the guidance of tutors John Taylor and Richard Smith, participants can indulge in 'hands-on' use of all the equipment. This year's School will take place between 24 - 28 July. Anyone requiring further details should contact the course secretary, Jane Staton at Loughborough College, Radmoor Road, Loughborough, Leics. LE11 3BT. Tel. 01509 215831 Fax. 01509



HAND TURNING

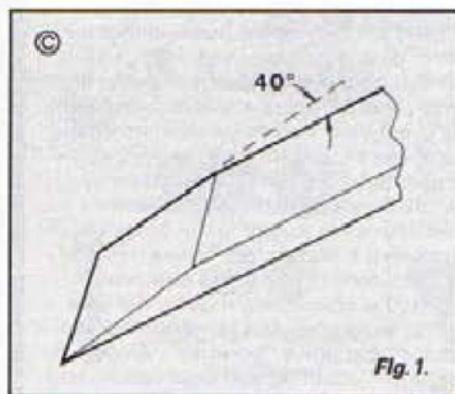


Fig. 1.

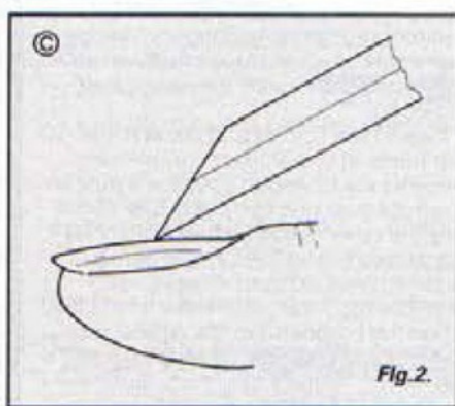


Fig. 2.

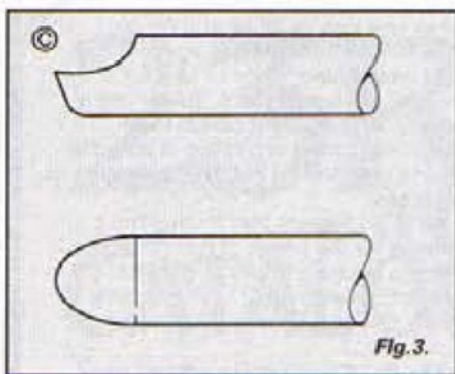


Fig. 3.

Gordon Read introduces us to a technique which will allow expression of our artistic abilities as well as providing a means of saving time

We all know that the sawdust fraternity do all their turning with hand-held tools, but while some of us use hand tools on metal in the lathe, others have only heard about it and there are a lot who don't even know that it's possible. Time to change all that!

The obvious question is why bother with such an apparently outdated technique when we can get shapes by twiddling knobs? Simple. Try, for example, doing that to make a little gauge '1' size finial for the top of a signal post; you'll soon see the problem. Who said 'form tools'? Often you only want to make one of the article in question. With hand turning it's easy; easier, in fact, than describing it. Putting this lot into words is rather like the traditional author's challenge of describing a spiral staircase to a person who has never seen or heard of a two-storey building!

Toolmaking

The next objection, of course, will be 'where do I buy the tools?' You don't; you make them. Two will do just about everything, although others can be made if you wish. The two basic ones are a round-nose and a thing called a graver.

A graver starts off with an old square file. These always taper towards the end, so that bit is removed. Put the file in the vice with the unwanted taper end bit sticking out, cover it with a cloth as a safety measure, then hit it with a hammer. It will break off near the vice jaws. Get it red-hot

and let it cool slowly so as to be soft. When cold, grind or file off the teeth, enough to feel comfortable in the hand. Take the teeth off completely for about the last inch at the broken-off end, away from the tang. That part needs to be as smooth as you can get it. Finally, file the broken end to a shape as per Fig. 1. Aim for the edges to be as sharp as you can get them on the two 'corners' which join at the end point.

Having done all that, harden and temper to straw colour. No need to do the whole length; the end couple of inches is quite enough. Next, stone the flat end and the sides which meet it until all is sharp. The final test of sharpness is to hold it against your thumbnail as per Fig. 2. If it slips forward, the point isn't sharp.

A round-nose tool is made in exactly the same way, but from a round file or a length of silver steel rod. Shape the end as in Fig. 3, with an end radius of about $\frac{1}{8}$ in. The easiest way to get a round-nose is to find one of those sharpening steels which used to come with table carving sets; the weapons father used to use to carve the Sunday joint! The steels are lovely hard tool steel, and only need to be ground to a suitable end. Even the handle comes with it. I've used one for years. (Photo 1)

A point about tool length needs bringing out. The longer the tool, the better is the control of the cutting point. For a beginner, a tool length of 9 to 12 inches is about right, but, for some jobs you'll eventually find that a long tool can't be got into some of the places you want, because something like the tailstock gets in the way. So, eventually you'll decide to make some shorter ones.

Now to using the tools. Start with either aluminium or free-cutting BMS as a material. They produce nice curly swarf which lets you know how well you're cutting. Brass doesn't do that, as we all know, so leave brass until you've got the hang of the technique. Of course, you've fitted the tools with nice firm file-handles: I always set mine in with a smear of Araldite

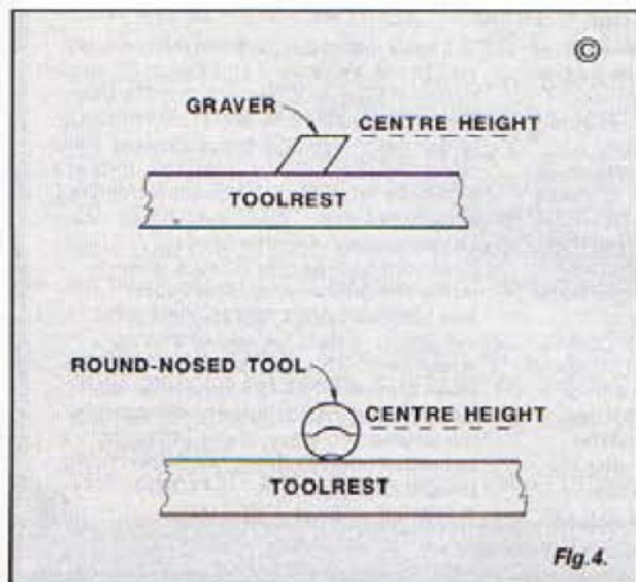


Fig. 4.

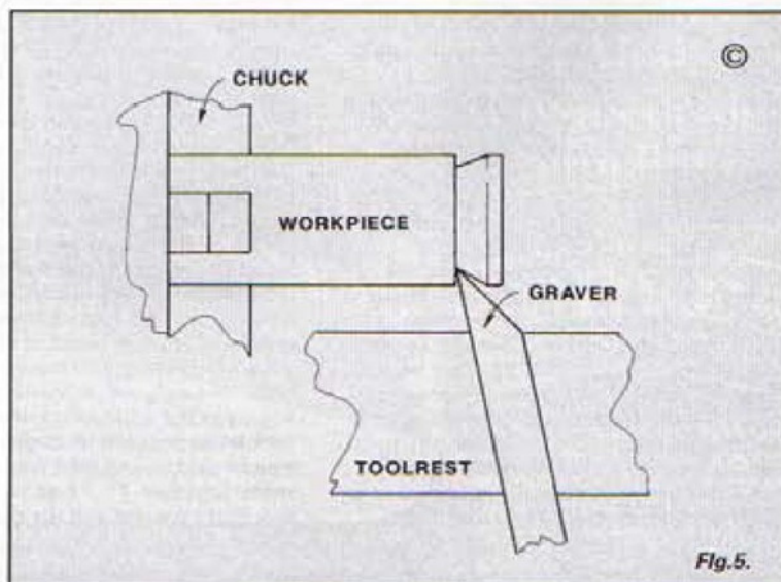
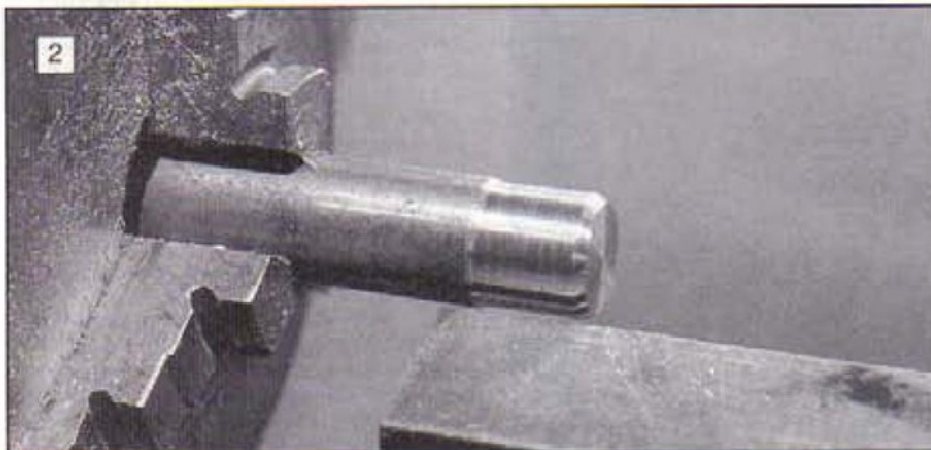


Fig. 5.



1. A graver and a round-nose tool. The round-nose is made from the 'steel' from an old-time table carving set.



2. A chamfer done with a graver.

just to be sure.

You need a hand rest in the toolpost. A bit of steel bar about 1in. wide and at least $\frac{1}{4}$ in. deep is ideal. Have about 4 to 6 inches of it projecting from the clamp, towards the chuck. For first attempts, pack the rest up so that the tool point is at lathe centre height when the tool is flat on the top of the rest, as in **Figure 4**.

Mandrel speed should be about the same as you would use for 'ordinary' turning. For a first attempt, the workpiece bar should be somewhere between $\frac{3}{4}$ in. and 1 $\frac{1}{2}$ in. diameter. All ready? OK—now comes the author's challenge of describing how to hold the tool!

Holding the tool

Try the tool positions without the lathe running at first. Hold the handle in the left hand from above. Take a good grip, because if the point digs in, the handle jumps sharply upward. It's not as strong as you, but you should be ready for it just in case. The right hand holds the graver on to the rest. The right hand has two jobs to do, but only one at a time. Job No.1 is to act as a pivot point when you swing the handle in a horizontal arc. Job No.2 takes a bit more practice, and is to act as a sliding clamp, so that you can draw the tool along the axis of the workpiece. With a graver held as in **Fig. 4**, there's no top rake to the cutting edge. That's fine for brass and cast iron, but not for aluminium or mild steel, so for them you rotate the handle a little until the desired top rake is obtained. Now, the graver isn't resting a flat side on the rest;

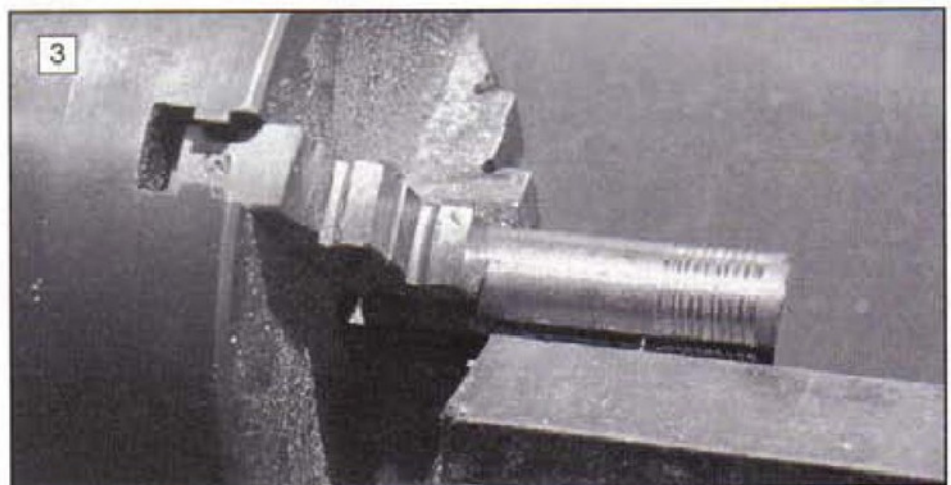
it's standing on one corner of the shank. Just needs a bit more firmness in holding it! Once you've got the hang of those ideas, start up the lathe and we'll cut metal.

Practice cuts

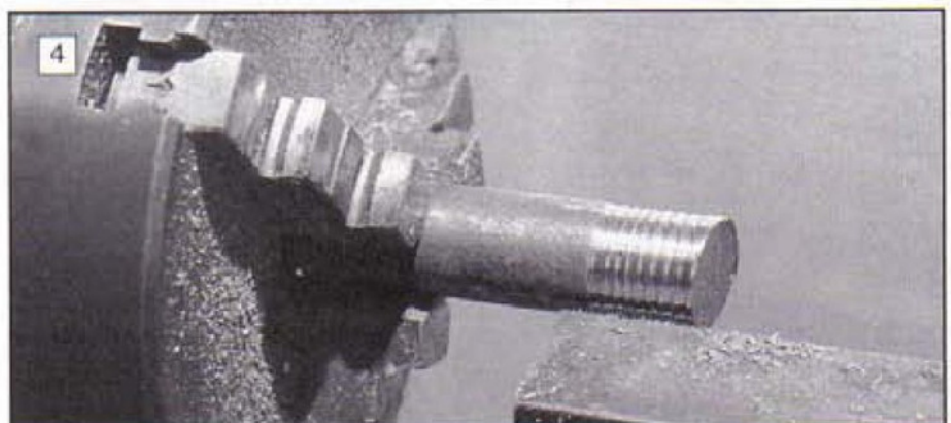
For a start, try a chamfer on the end of the workpiece. (**Photo 2**) The end, if it wasn't parted off, probably won't be running true. For your first try, it's a good idea to use the cross-slide to face it off before starting with the graver. Later, that won't be necessary.

Hold the graver firmly as already explained, and bring the cutting edge up to the work. Take a very light cut to chamfer the end; nice curly swarf should be produced. If not, rotate the tool a bit one way or the other until you get it; that's the right top rake angle. When you've got the idea, widen the chamfer. There comes a point at which the tool starts to chatter. Keep below that point, because it's the widest cut you can take smoothly. The next stage will show how to get wider surfaces done.

Now comes turning the cylindrical surface of the bar. If your 3-jaw is anything like mine it won't run dead true, so the unturned work surface will be running a bit eccentric. That has to be got rid of. Start at the end of the work away from the chuck and apply the graver as shown by **Figure 5**. When the cut starts, it won't be right round the bar, so the tool will try and jump about a bit. Show it that you're stronger than it is, and only take a cut with the bit of



3. Initial turning showing graver grooves.



4. Initial turning showing 'round-nose' grooves.

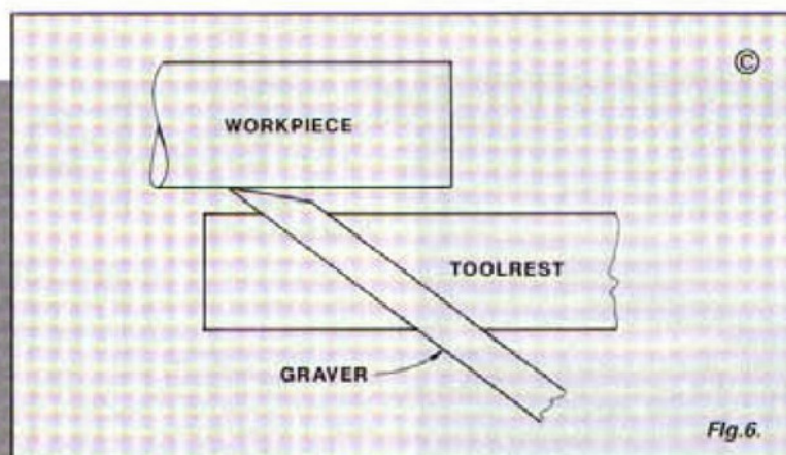


Fig. 6.

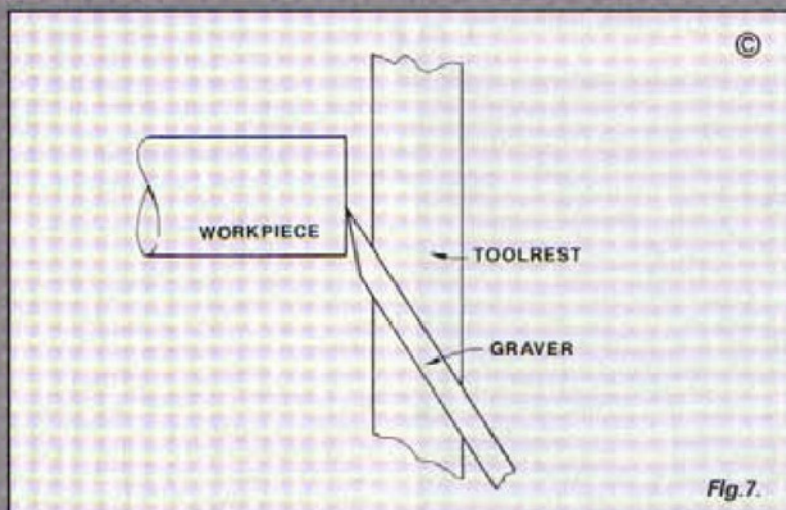


Fig. 7.

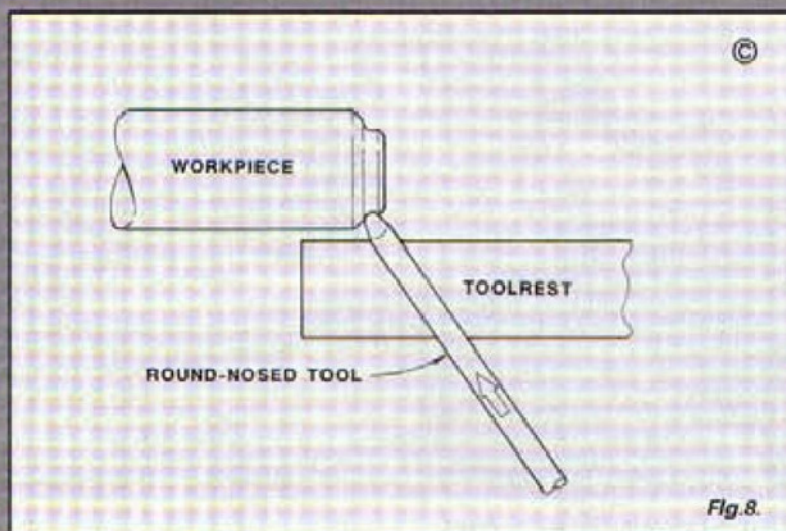


Fig. 8.

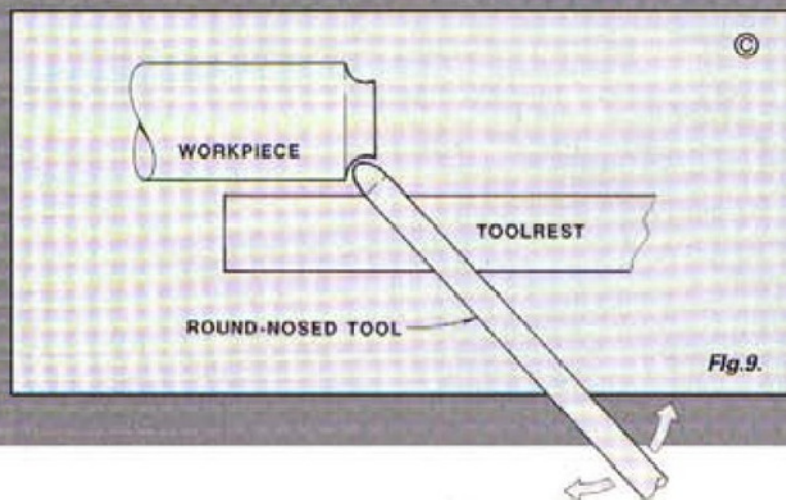


Fig. 9.

the edge very near the point. When it's cutting all round, you'll have a tapered ring turned on the bar. Move along towards the chuck, and do another one almost overlapping the first. Continue like that along the length of the workpiece. The result will be like the thing in Photo 3. It has to be made into a smooth surface, which brings in the second of the jobs required of the right hand.

Have the graver point facing the chuck as in Figure 6. With the right hand used as a sliding clamp, draw the graver steadily away from the chuck and parallel with the lathe mandrel. This will remove the tops of the ridges, and successive cuts will eventually produce a smooth cylinder. No guarantee, of course, that the cylinder isn't a bit tapered; for a first attempt it probably will be. It's quite possible to get an almost perfect cylinder with practice, but remember that in general, we don't intend to use hand turning to produce work to the last thou. End of first lesson!

By now, confidence should be growing, so, if you feel fully in charge, now is the time to be told that you don't have to keep the graver flat on the rest all the time. The wood turners don't, and we don't have to either. Sometimes it's more convenient to angle the tool up or down and it removes the need to have the rest at an exact height. The cylindrical surface can be turned just as well with the round-nose tool; some folk prefer it. Instead of making a series of little tapers and then removing the ridges between them, you make a series of grooves with the end of the round-nose and then remove the ridges. To make the grooves, go straight in radially with the point of the tool (Photo 4), then, do the same again to remove as much as possible of the ridges. Finally, draw the tool along as was done with the graver, to produce a smooth surface. One tip about the round-nose, though. You can widen the grooves easily by slightly rotating the tool on its own axis while it's cutting. Up to you whether you settle for graver or round-nose, but I think you'll find that the graver is the best weapon for the final smoothing off.

Facing comes next. Facing right into the centre of the workpiece end is the tricky bit, so for first tries, put a centre-drill into the end before you start. The trick in facing right down to the centre of the workpiece without leaving a 'pip' or having a tool dig in, lies in accurate control of the tool point in the vertical plane. Nothing to fuss about, but it does take a bit of practice.

Facing can be done with either of the tools. Whichever one you decide on, the cut starts at the centre of the work and runs outward to the edge - every time! Hold the tool as shown by Fig. 7, in which you'll notice that the rest has been swung 90deg. from where it was before. Keep the tool at a constant angle to the work and draw it radially outward across the face being turned. As for the cylindrical surface, don't expect a perfect flat surface first time but, as a yardstick, it's amazing how accurate is the work that the wood-turners produce. (Photos 5, 6 & 7)

Fancy turning

Having now got a true-running piece, faced and turned, we can have a go at

fancy shapes, which would otherwise call for making form tools. Start with the chamfer. We're going to make it into a concave curved surface. Firstly, widen it with the graver, used in a series of successive cuts. Smoothness of the resultant surface doesn't matter. When the chamfer is about $\frac{3}{8}$ in. wide, go straight in at the centre of it with the round-nose tool. Having got a nice deep groove there, swing the tool handle from side to side to widen it. Varying pressure forwards and position sideways will transform the original chamfer into a concave surface (**Figs. 8 & 9**). You can expand the concave surface to any width you want, of course, but it will always have sharp edges where it meets the face and the cylindrical surface. Next stage is to make the outer of those two sharp edges into a convex curve.

To make the convex curve, put the hand-rest back parallel to the lathe mandrel and pick up the graver. General rule here; round-nose for concave surfaces and graver for convex ones! Chamfer the sharp corner and then swing the graver handle in a horizontal arc to produce a convex curve. **Figure 10** shows the idea. Doing that is, in fact, about the easiest operation in hand turning.

So far, we've arrived at the position where we can make a concave surface with a convex one blending it into a flat surface, but there will be times when the reverse is required; a central convex surface between two concave ones. No problem in that; just make the two concave ones first, at the right distance apart, and then use the graver to make the bit in between into a convex curve. Granted, there's not a lot of space, and you have to use the very end of the graver, but it's only a matter of developing a bit of manual dexterity.

The next thing to try, because it's the lead-in to other things, is fine ornamental grooving. It's done with the point of the graver. In other words, we hold the graver with the point upwards and one corner of its shank on the rest. **Figure 11** shows the idea. In that position, the tool is fed straight into the work to make a fine groove about $\frac{1}{32}$ in. wide at the most. The cutting is in fact partly a scraping action, but it does the job. However, the longer the tool shank the better, because it's all too easy to have the tool chatter to a very small extent. You don't even know it's happening, and there are little bright dots at the bottom of the groove! Those tiny grooves are the start of making 'square section' depressions in a cylindrical surface. You do two of them to define the edges of the desired depression, and then deepen them with the graver held as per **Figure 12(a)** and **(b)**. That gives you two grooves, each with one side at 90deg. to the surface and one at an angle to it. Having done that, the space between them is turned out to form a flat bottom. This isn't really the best job for a graver; it's better done with a square-ended tool, but you can always cheat and use the parting tool in the 'normal' way!

Opening out a centre-drilled hole to make a concave depression in the centre of a faced surface is done with the round-end tool. Set the rest at 90 degrees to the lathe mandrel axis, and go straight in at the centre, but with the tool pressure towards you so that it cuts only at one side of the work. I know that 'sideways towards you' is a bit of a contradiction, rather like the man

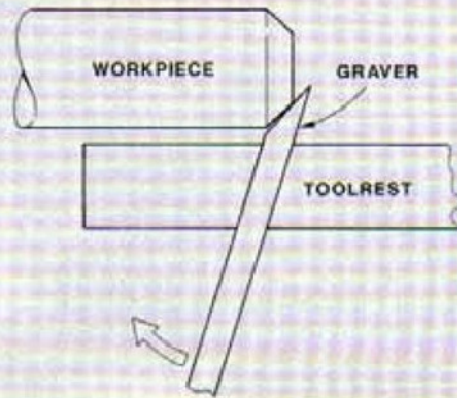


Fig. 10.

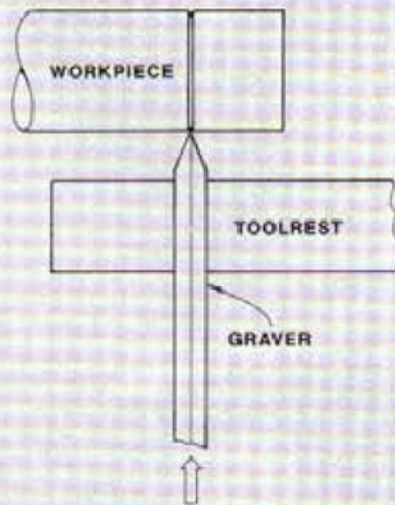


Fig. 11.

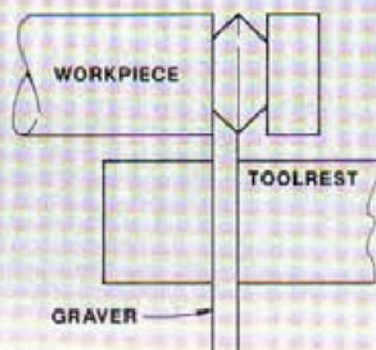
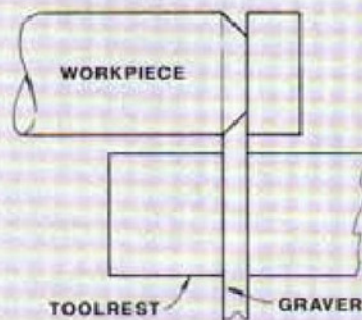
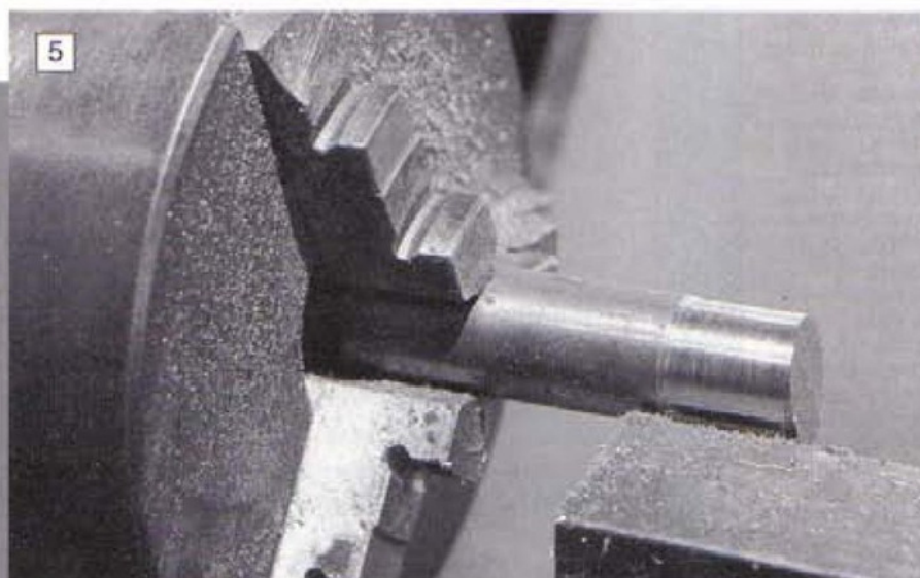
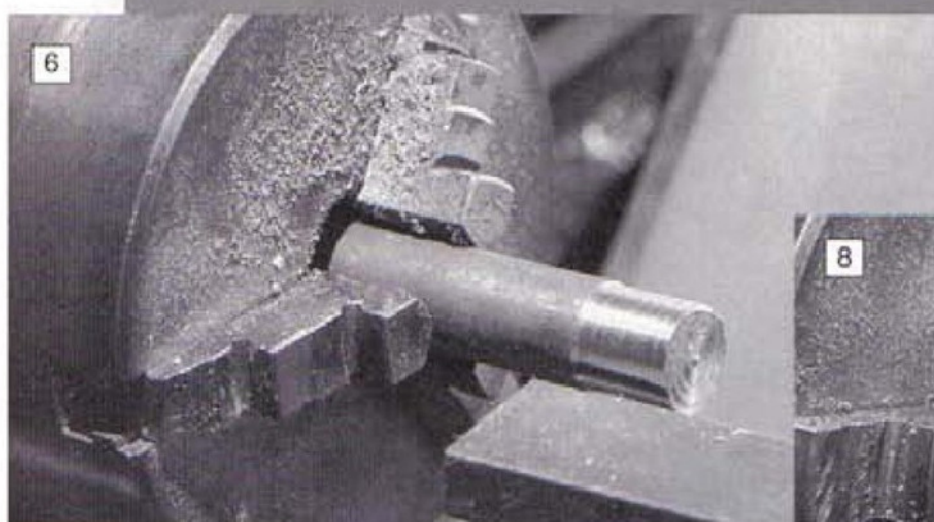


Fig. 12.

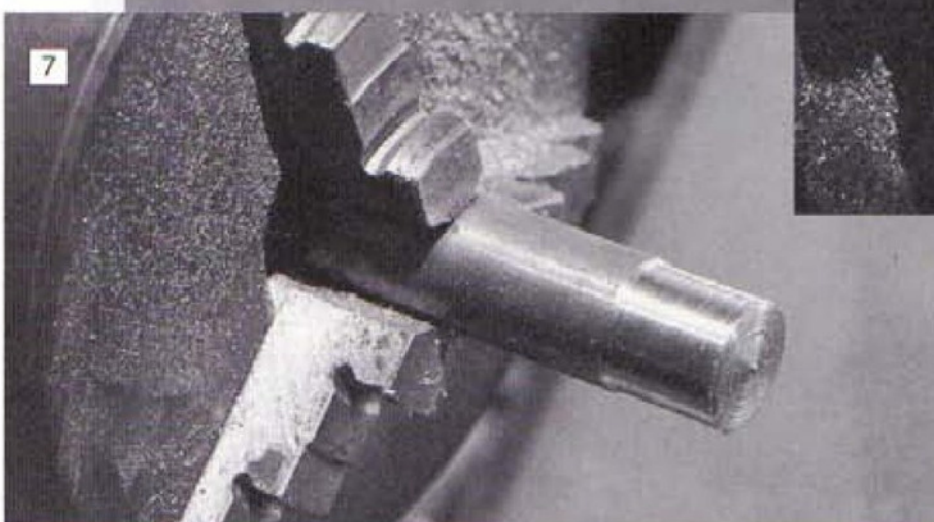
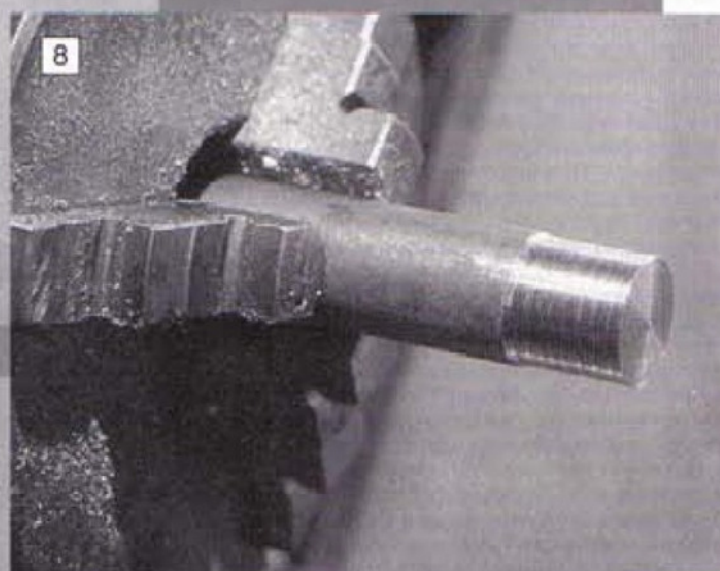


5. The turned surface smoothed off, but the end of the bar untouched.



6. The end partially faced.

8. The end fully smoothed off.



7. The end fully faced, but still rough.

who said 'there's two entrances to the way out', but if it gets the idea over.

As you cut, the centre-drilled hole will get bigger and roughly bowl-shaped. Keep on until it is whatever size you wish. Keep to the round-nose; a graver is useless for this job. The thing can be expanded to making, if you wish, things like egg-cups.

The various photos of jobs done should give some idea of the range of possibilities opened up by hand turning. Look at it this

way. Normal turning can produce any combination of cylinders, cones and radial faces; beyond that it can't go. Anything which goes beyond that specification is a natural for hand turning, provided that dimensional accuracy isn't the prime consideration. There's no need to make a big deal of it; the roughing out before hand work can often be better done by the 'normal' methods, and that's always worth considering, because hand turning

can't take huge cuts.

Even if you don't intend to do a lot of this, always have a graver by the lathe: it's just the job for 'breaking' those sharp edges. Just hold it with the cutting edge at 45 degrees to the edge and take a fine skim.

Finally, hand turning allows production of 'ornamentals' to justify the workshop to 'she who must be obeyed'!



CRANKSHAFT RECONDITIONING TECHNIQUES

With many years experience as a Professional Engineer in the automotive engineering trade, Ted Hartwell is well qualified to describe the refurbishment of the component which lies at the heart of the i.c. engine

This article is intended to follow two published earlier in *Model Engineers' Workshop* - that dealing with the white metallising of heavy shell bearings by Fettler (Issue No. 13), and the subsequent one by the same writer in respect of the machining and fitting of such bearings as used in veteran, vintage and classic car engines (Issue No. 28).

The subject matter has been expanded to include the servicing of current car engine crankshafts, together with a section introducing the basics of dynamic balancing. The principles and practices outlined may also be found to be of

assistance in the regrinding of marine, industrial and some motor cycle crankshafts, as well as compressors and pumps.

The initial examination of the crankshaft.

Preparation

Having removed any oil plugs from the shaft (these may need to be drilled out, retaining details of the plug length for replacement purposes), the crankshaft should be thoroughly cleaned both internally and externally with any carbon

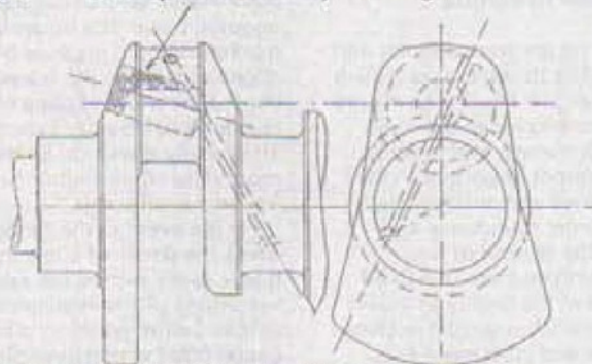
deposit on bearing surfaces removed by the use of a brass wire brush. The timing gear or sprocket can be left in place at this stage unless wear is excessive. Similarly, the gear box first motion shaft bush in the flange end need not be removed. (Removal if necessary, can be effected by filling the bore with heavy oil and driving a close clearance peg into the bush with a two pound hammer - the resultant hydraulic pressure will 'jack' the bush out). Should the shaft be fitted with detachable balance weights, these need only be removed (after first having stamped their positions) if the shaft needs regrinding.

The internal cleaning of the crankshaft is particularly important. Sketch No.1 shows how sludge and debris can build up by centrifugal force on some shafts, ultimately blanking off the crankpin oil feed.

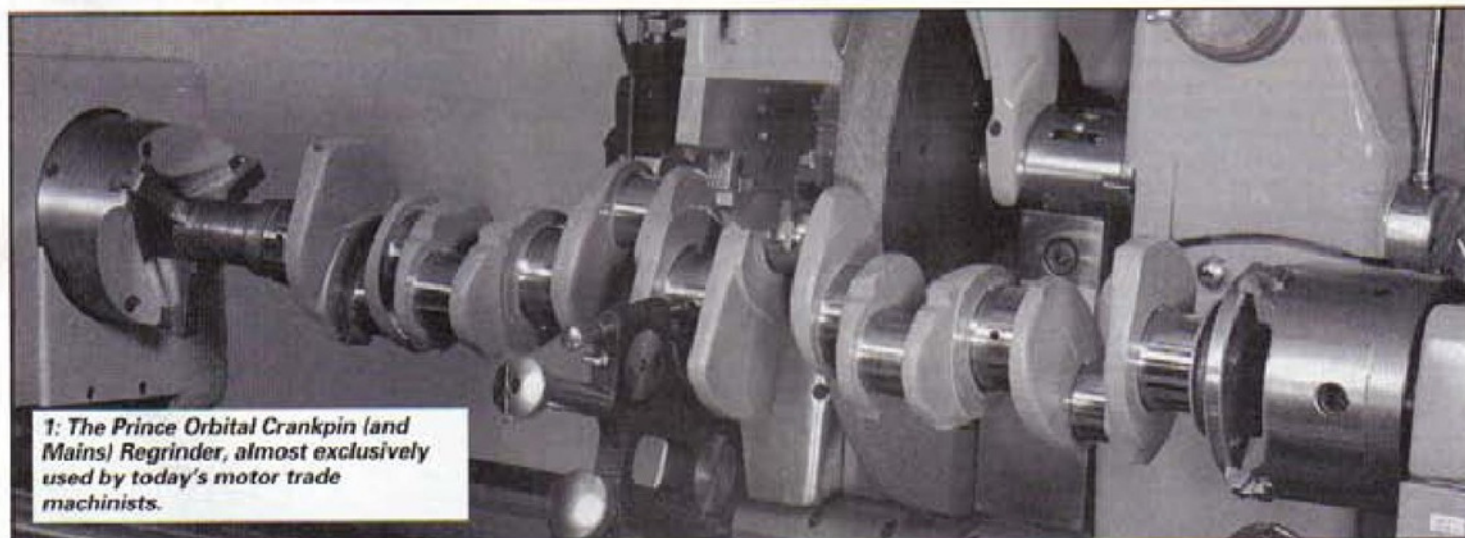
Crack Detection

Holding the crankshaft vertically by several fingers under the flange end web, tap an opposite end web with a light hammer. A sound shaft will ring like a bell, whilst a flat note suggests a possible crack, which should be followed up by crack detection at your local motor trade machinist. (Most early Ford shafts and a substantial proportion of current shafts are

© Sketch No.1 Build up can eventually block big end oil feed



Sludge trap effect of lightening holes in crankpin



1: The Prince Orbital Crankpin (and Mains) Regrinder, almost exclusively used by today's motor trade machinists.

of cast material - see the material schedule - and may not 'ring' in the same manner as those of forged steel). Similar comments apply to crankshafts fitted with separate balance weights. In no circumstances should a shaft failing crack detection be re-used.

Checking for bow

With the crankshaft between centres or supported on Vees (simple plywood 'Vees' can be improvised for this purpose) under the flange and spigot diameters, rotate the shaft and measure any 'runout' at the unworn areas of the main journals. A T.I.R. (total indicator reading) of more than two thou on a four throw shaft, or three thou on a six is the maximum normally acceptable, although five thou may be tolerated on some early engine shafts having small diameter journals.

Excessive bow of up to say twenty thou T.I.R. can be accommodated by re-grinding, but this will make the re-grinding of all crankpins essential to correct both stroke and alignment, together with the refacing of the flywheel flange location face. The straightening of crankshafts under a press is not considered acceptable to-day but, as a last resort and when the shaft is known to be made from forged steel and not subsequently hardened or nitrided, it can be judiciously used followed, of course, by crack detection.

A more acceptable method of straightening shafts is by localised rolling or the use of specially shaped 'indenters' on specific sections of the fillet radii, to introduce compressive stresses in those areas, but as far as the writer is aware, these techniques are not generally available through motor trade machinists.

Journal wear/condition

Bruised or scored journals and/or combined taper and ovality in excess of one and a half thou will necessitate the re-grinding of all similar bearings (crankpins or mains) to a similar size. Should the engine be fitted with thin wall shell bearings, the original journal standard size (together with the available undersize shells) is normally stated in replacement bearing catalogues and should be used as a reference when checking journal diameters for wear.

In the case where a big end bearing has failed and badly scored an individual crankpin, it is permissible to re-grind this particular pin to an odd undersize (or just clean up in the case of a direct metallised rod or one fitted with a heavy shell bearing), the normally acceptable maximum undersize being sixty thou. Should the associated connecting rod be fitted with heavy shell bearings, it is desirable to make a new pair with undersize bores (prior to white metallising), to reduce the otherwise excessive lining metal thickness.

Thrust or location faces should be carefully examined. There is little problem in cleaning these up where heavy shell bearings or direct metallised rods are employed. However, 'thin wall' main bearing thrust washers are normally available in a standard oversize (see the replacement bearing catalogue). In the

unlikely event of 'thin wall' bearing crankpin faces needing attention, one side of the associated connecting rod can be built up, preferably with white metal, to restore the original clearance (eight to twelve thou).

Should the shaft be found to be in an acceptable condition, the journals can be lightly polished with 400 grit abrasive tape. As an added check, crankpin alignment with the main journal axis can be checked with the shaft in matching Vees (or between centres) when the maximum 'run', both at TDC and at 90 degrees, should be 1 in 5000, i.e. under half a thou at each end of a typical journal.

The re-grinding process

While this will normally have to be entrusted to a motor trade machinist, the following information will assist the reader in understanding the process and ensuring workmanship suited to his/her particular requirement.

There are two basic types of crankshaft re-grinding machine in common use to-day - the conventional 'throw block type', similar to those used in crankshaft manufacture - and that specifically manufactured for crankshaft re-grinding, where the shaft is rotated on its main journal axis (usually with a chuck at one end and a centre at the other), the grinding wheel following the crankpin orbit by means of a captive vee. Both types grind the main journals between centres (or a chuck and a centre), both having advantages and potential disadvantages.

The Throw Block Machine

This type relies on accurate angular and radial alignment of its throw blocks (which can be Vees or three jaw chucks) to ensure parallelism of the crankpins to the main journal axis in both planes, and to obtain the correct stroke (most important in the case of diesel engines and, incidentally, compressors). Journal roundness and parallelism are in the control of the operator by the combined use of a fixed two point steady and the facility to adjust the horizontal relationship (angle) between the grinding wheel and workpiece axes. Correct counterbalance also features in the achievement of round journals.

Normally, for economic reasons, the grinding wheel is narrower than the journal being ground, requiring side traverse to grind the total width of the journal, although the majority of metal removal should be by plunge cutting. However, the unavoidable use of the 'corners' of the grinding wheel tends to produce a 'waisted' or 'hourglass' journal profile (but which is barely measurable) resulting in the 'hard marks' one often sees at the edges when bearings are subsequently fitted. The machines used in crankshaft manufacture have wheels of similar width to that of the journal, profiled under computer control, to produce a marginally 'barrelled' journal by plunge grinding, followed by superfinishing on a separate machine, still avoiding the 'waisted' or 'hourglass' tendency.

The Orbital Machine

This design of machine copies the existing throw of the crankpin. Due to normal wear taking place on the underside of a journal, there is a tendency to increase the throw and, therefore, the stroke of the crankshaft. On earlier machines this had to be corrected manually, but later models have built in compensation. Additionally, a special vernier gauge enables the stroke to be accurately measured, ensuring that the original dimension is reproduced within acceptable limits.

Due to the construction of the machine, and because the crankshaft rotates on its main journal axis, ovality and taper are not normally a problem, although the use of a 'narrower than journal width' grinding wheel still tends to produce a slightly 'waisted' profile. Final finishing is generally carried out using a hand applied scissors type lap which, if not skilfully used, can worsen the 'waisted' or 'hourglass' tendency.

Tolerances and special requirements

For satisfactory bearing performance, combined ovality and taper should not exceed 0.0003in., with a maximum surface roughness of eight micro-inches. Again the motor trade machinist should possess a means of surface finish measurement or, at least, a set of roughness standards - slips of metal having specific surface finishes for visual and tactile comparison purposes.

Alignment has already been referred to - a maximum 'run' of 1 in 5,000. Due to its design, the orbiting type of machine should achieve this level of accuracy on an ongoing basis. The throw block design of machine should produce acceptable alignment due to the operator's ability to check the runout of pairs of pins on conventional four and six throw shafts. This facility does not, however, exist when regrinding crankshafts where no two pins are on a similar axis.

In the event of the reader deciding to check the stroke of a reground crankshaft, this is easily carried out with the shaft in vee blocks or between centres, using a vernier height gauge or a suitable calliper gauge fitted with a base block as described in an earlier issue of Model Engineers' Workshop. As a further alternative, the shaft can be supported under its end main journals on two pieces of say 3in. x 1in.

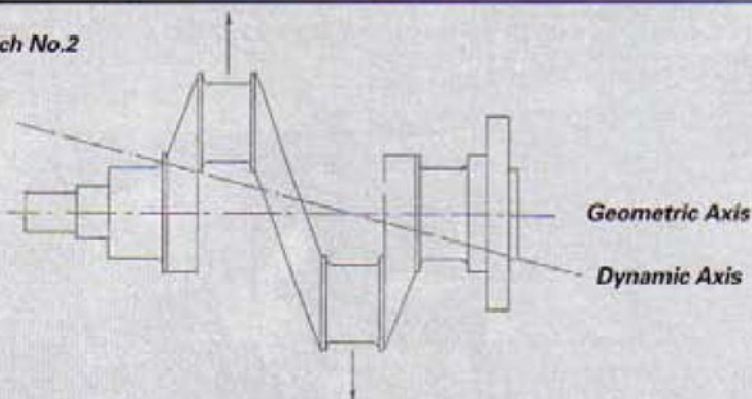
QUICK TIP

Scribing block fine adjustment.

If you do not have one of those posh scribing blocks with a fine adjustment screw, put a slight bend in the straight part of the scriber. Now, if you slacken off the clamp slightly and rotate the scriber using the end which is bent at right angles, you will find that your surface gauge has fine adjustment.

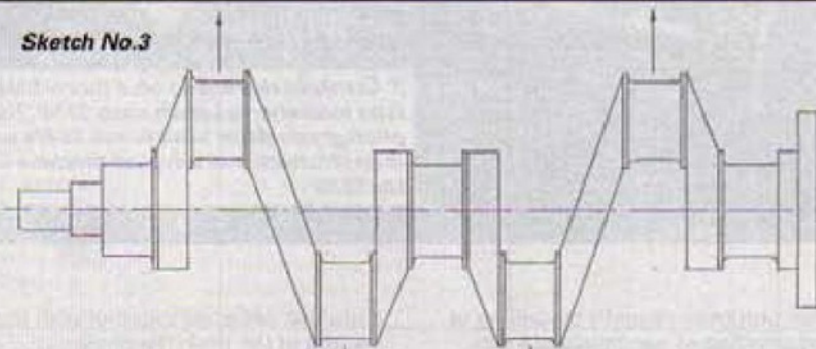
Gerry Riel

© Sketch No.2



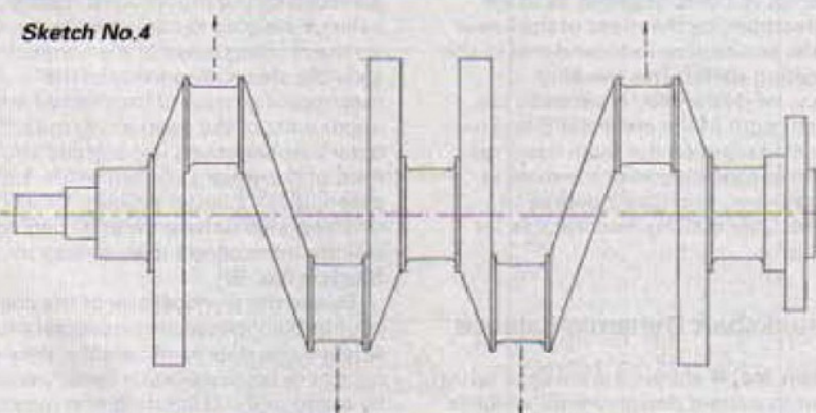
Two throw shaft in static balance — dynamic unbalance in direction of arrows creating vibration and substantial additional loading on main bearings

© Sketch No.3



Four throw shaft in dynamic balance but with lack of counterbalancing creating additional loading on main bearings due to bending moment in crankshaft

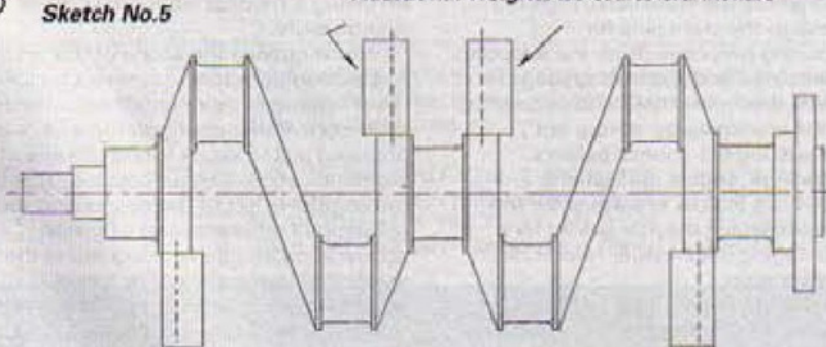
© Sketch No.4



Four throw shaft in dynamic balance with limited counterbalance substantially reducing the additional load on main bearings, the size of these weights is not sufficient to compensate for the centrifugal effect of the big ends of the connecting rods.

© Sketch No.5

Additional weights bolted to crankshaft



Fully balanced crankshaft providing partial compensation for the reciprocating masses of pistons and upper ends of connecting rods



2: Stroke measuring vernier gauge.

bright flat stock or gauge plate and a short length of $\frac{3}{4}$ in diameter bright bar faced to pass under a crankpin at its lowest point. The combined length of this piece of bar and the feeler gauge used to just contact the underside of the pin can, in conjunction with the measured width of the parallels used and the main and pin diameters, be used to calculate the crankpin throw and, therefore, the stroke. The resultant accuracy should be comparable to that obtainable by the use of a vernier gauge. The permissible stroke deviation from standard (normally contained in replacement piston catalogues) is typically plus or minus three thou in the case of diesel engines and compressors and about plus or minus ten thou for petrol engines.

Other aspects of reconditioning

There is, in the writer's opinion, no acceptable method of building up excessively worn crankshaft journals - such shafts should be scrapped. However, timing gear and/or fan pulley seats - including key seats, can be recovered by careful welding, these being comparatively unstressed areas. Similarly metal spray or electro-plating can be used to re-establish the interference fit of the timing gear

QUICK TIP

Cleaning 'T' slots.

I have a powerful but small rectangular magnet which slips into the 'T' slots of my machines, thus easily cleaning out ferrous swarf.

Hubert Eiflers

and/or the fan pulley.

Rear oil seal diameters and return scrolls may need attention following excessive bearing wear, but should be reduced in diameter with recut scrolls.

Compensation for the metal removed can be made by the use of undersize or built up oil retainers.

On completion of the reconditioning/regrinding of the crankshaft, oil hole junctions with the journal surfaces must be carefully blended and oil drillings and pockets washed through to remove any traces of abrasive prior to refitting any oil hole/pocket plugs. Check that these are not long enough to blank off any cross drillings. Refit any balance weights removed for regrinding purposes, paying particular attention to the tightness and locking of the securing bolts. If not to be fitted immediately, the shaft should then be lightly oiled and stored in a clean plastic bag remote from sources of abrasive dust, such as that produced by an offhand grinder.

Balancing

Crankshaft, and the associated engine balancing is a complex subject, particularly from the aspect of design. Those involved in engine overhaul/rebuilding cannot normally change the inbuilt parameters but, by understanding the principles, can ensure that the resultant engine runs as smoothly, or even a little better, than when new. The basic elements and stages of balancing are as follows:-

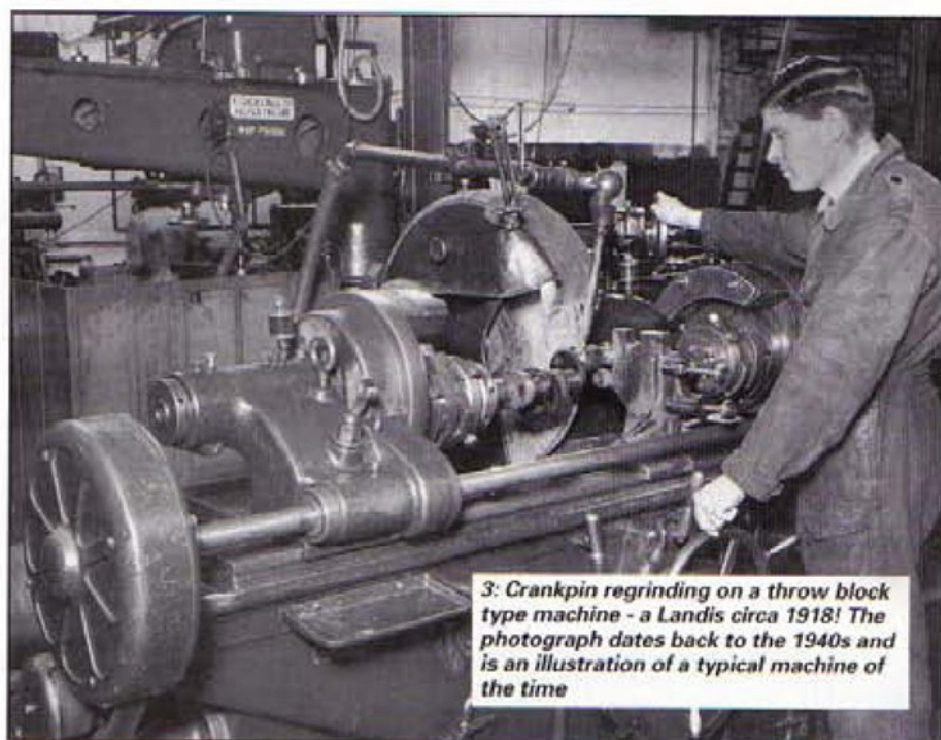
Static crankshaft balance

This, as its name implies, is the balance of a rotating unit - in our case a crankshaft - in a static mode (see **sketch No. 2**), typified by a basic two cylinder industrial engine or compressor. Rotation of the crankshaft, however, creates centrifugal forces acting in the direction of the arrows, causing a rocking motion which rotates with the crankshaft. The mass of the lower end of the connecting rods adds to the centrifugal effect, thereby worsening the situation.

To counteract the vibration induced by this unbalance (and that of the reciprocating parts), the cylinder block/crankcase must have appreciable mass - frequently assisted by its being bolted to a very substantial concrete foundation in the case of stationary engines or compressors. The constraining of the crankshaft to rotate on its geometric axis - that of the main bearings rather than its dynamic axis - shown as a broken line, imposes an additional load on the main bearings, equal or even more than that created by the cylinder pressures.

Basic Crankshaft Dynamic Balance

The term 'dynamic balance' implies the accurate correction of a crankshaft to ensure that, when rotated at modest speed on its geometric axis, the main journal centre line coincides within close limits to its dynamic axis. This is achieved by the use of a special purpose balancing machine, having floating main journal roller supports which sense and measure the angle and extent of any unbalance for



3: Crankpin regrinding on a throw block type machine - a Landis circa 1918! The photograph dates back to the 1940s and is an illustration of a typical machine of the time

corrective purposes - usually by drilling or localised grinding of non stressed areas.

Sketch No. 3 depicts a typical classic engine crankshaft which, when rotated at say 250 r.p.m. creates rocking forces which cancel each other out, i.e. the dynamic and geometric axes coincide. However, at a speed of say 5,000 r.p.m., the crankshaft will attempt to bend, assisted, as in the earlier example, by the mass of the lower end of the connecting rods (and that of the reciprocating parts). This bending tendency, while partially resisted by the tensile strength of the crankshaft, imposes additional loading on the main bearings. The internal cancellation of the rocking forces however, provides a degree of engine balance making it acceptable for vehicle use.

Full Crankshaft Dynamic Balance

Sketch No. 4 shows a crankshaft which is similar to current design where weights are provided to counterbalance the centrifugal effect of the mass of each crankpin (and its associated web sections). The actual physical dimensions and, therefore, the mass of these weights is restricted by the radius and width permitted within the crankcase, together with access to the crankpins for manufacturing purposes. With the adoption of shell moulded nodular iron castings for crankshafts, it is now possible to reduce the mass of the crankpins by 'coring out', thereby assisting the counterbalance. Earlier 'prestige' engine crankshafts frequently have hollow crankpins for the same reason, which may be sealed by a form of plugging - see earlier reference under Preparation.

The result of the provision of these additional masses is to reduce or eliminate the centrifugal effect of the crankpins and their associated webs plus, possibly, a degree of compensation for connecting rods. A further stage of balance is,

therefore, obtained together with reduced loading of the main bearings.

Combined Crankshaft and Engine Balance

This advanced stage of balance is achieved by the provision of heavier balance weights to compensate not only for the rotating mass of the connecting rods but also a proportion of the reciprocating mass of the pistons and the upper ends of the connecting rods. This latter compensation is generally about one third of the weight of each of the 'top end' assemblies - a larger amount resulting in unacceptable unbalance at 90 deg. to the cylinder bore centre line - shown in

Sketch No. 5.

Due to the physical size of the crankshaft counterbalance weights necessary to achieve this degree of balance, they may consist of separate items fixed (generally by bolts) to the crankshaft and requiring removal prior to crankshaft regrinding as noted earlier. The greater extent of balancing described above provides a further reduction in main bearing loads which, with resilient engine mountings results in a smooth running engine involving a modest additional cost of manufacture.

Whilst outside the scope of this article, further compensation or correction for reciprocating components can be made by differing cylinder configurations i.e. Vee, opposed piston etc. A further source of vibration - secondary unbalance - due to the angular effect of the connecting rod resulting in different rates of piston acceleration and de-acceleration at the upper and lower ends of its travel - can be reduced by contra-rotating balance weights running at twice engine speed, a solution invented by Dr. Lanchester early this century and adopted recently by one Japanese car manufacturer.

MATERIALS USED IN CRANKSHAFT MANUFACTURE AND SUGGESTED RECOVERY ACTION.

FORM OF MATERIAL AND CONDITION.	SPECIAL TREATMENT DURING MANUFACTURE.	ACTION IF BOWED.	PERMISSIBLE UNDERSIZE LIMIT.	PRECAUTIONS NECESSARY WHEN REGRINDING JOURNALS.
Heat Treated Alloy Steel Forging.	None.	Grind out or Scrap, Straighten as last Resort.	Minus .060".	Normal Grinding Techniques.
	Induction Hardened Journals.	Grind out if minimal or Scrap. Do not attempt to Straight- en.	Normally minus .040" but see Note 1.	Use light cuts with free- cutting wheel and copious Coolant.
	Nitrided Journals.	Scrap, but as last resort grind out and Re-nitride. Do not attempt to straight- en.	Minus .060" subject to Re-nitriding but minus .010" may be possible without.	As above and with extreme care at fillet radii. If Re-nitrided polish to re- move white surface layer.
Heat Treated Semi-steel Casting - typically Classic Ford and Fordson.	None.	Grind out or Scrap. Do not attempt to Straighten.	Minus .060".	Normal Grinding Techniques.
Meehanite Iron Casting - used by Scammell and Alvis, also some Air Compressors for a period of about ten years after World War Two.	None.	Grind out or Scrap. Do not attempt to Straighten.	Minus .060".	Normal Grinding Techniques.
Heat Treated Shell Moulded Nodular Iron Castings. In common use to-day in current Engines and Compressors.	None.	Grind out or Scrap. Do not attempt to Straighten.	Minus .060".	Normal Grinding Techniques but see Note 2.
	Undercut and Rolled Radii.	Scrap, do not attempt to Straight- en.	Possibly minus .010" but see Note 1.	Normal Grinding Techniques but Radii must not be re-ground or damaged but see Note 2.
	Undercut and Rolled Radii with Induction Hardened Journals.	Scrap, do not attempt to Straight- en.	Possibly minus .010" but see Note 1.	Use light cuts with free cutting wheel and copious Coolant. Radii must not be re-ground or damaged but see Note 2.
	Induction Hardened with untreated Radii.	Scrap, do not attempt to Straight- en.	Possibly minus .040" but see Note 1.	Use light cuts with free cutting wheel and copious Coolant but see Note 2.

NOTE 1.

THE MAXIMUM UNDERSIZE BEARINGS LISTED BY THE ENGINE MANUFACTURER WILL IDENTIFY THE PERMISSIBLE EXTENT OF RE-GRINDING. SHOULD STANDARD SIZE BEARINGS ONLY BE LISTED THE SHAFT MUST BE REPLACED AND NOT RE-GROUND.

NOTE 2.

DUE TO THE SPHEROIDAL FORM OF THE GRAPHITE IN NODULAR IRON THE GROUND SURFACE WILL EXHIBIT MICROSCOPIC CAVITIES WHICH CONTAIN A MINUTE BURR ('CAT'S FUR EFFECT'). ALL JOURNALS SHOULD BE RE-GROUND WITH THE SHAFT ROTATING IN ITS OPERATIVE DIRECTION BUT MUST BE SUBSEQUENTLY POLISHED WITH SAY 400 GRIT ABRASIVE TAPE WITH THE CRANKSHAFT ROTATING IN THE OPPOSITE DIRECTION.

Suggested action for the re-balancing of a reconditioned crankshaft

Specialist motor trade machinists may have dynamic balancing facilities available to the general public. However, the benefit is limited to the 'running up' of symmetrical shafts (preferably with the flywheel and clutch assembly, less clutch plate, attached) and achieving a state of dynamic balance, typical tolerances being between one fifth and one half of an ounce at one inch radius measured at each end of the shaft.

On single cylinder and non-symmetrical shafts, where no two crankpins are on a common axis, balancing is only possible by the attachment of specially calibrated bob weights to each crankpin, the details of which are unlikely to be available to the normal enthusiast and their calculation being difficult in the absence of original design data.

The only other facility in respect of balance available to the re-builder is to ensure that the weight of the big ends of the rods, when supported by the gudgeon pin is similar, together with that of the weight of the pistons and 'top ends' of the rods when supported at the big end joint line.

Crankshaft failure/fracture

While recent years have seen a substantial increase in crankshaft loads, failure is almost unknown. Those who

undertake engine overhaul can, however, unknowingly create a situation which can increase the risk of such failure. Some of these are as follows:-

Undersize or malformed radii

The junction between the journal diameter and the fillet face is a highly stressed area. The radius at this point must be of similar size to that originally provided by the manufacturer, having a surface finish comparable to that of the adjacent journal and blending smoothly with both the journal and the fillet face. On no account should the radius of a shaft having rolled surfaces be reground or otherwise damaged - see schedule of crankshaft materials and treatment. Rolled radii are normally recognisable by their smooth surface and slight undercutting below that of the journal, which may also be induction hardened.

Aggressive journal grinding

Extreme care is required when regrinding induction hardened or nitrided crankshafts to avoid the formation of microscopic surface cracks created by the use of the wrong grade of grinding wheel, poor diamond dressing and/or an excessive rate of metal removal.

Fatigue failure

Due to the reciprocating loads imposed on the crankshaft via the crankpins, torsional stresses are created which tend to 'wind up' and 'unwind' the shaft, particularly in the case of six cylinder engines. While this feature is allowed for at the design stage, resort is frequently made to the fitting of a torsional vibration damper at the end remote from the flywheel. Several types exist - that fitted to earlier engines normally being of the friction type where a small flywheel, or disc, is driven from its hub by spring loaded 'clutch' faces. Such examples may require the removal of similar amounts of metal from both the friction and mounting faces to restore the original relationship and, therefore, the applied pressure. If in any doubt, other types such as those having bonded rubber components should be replaced to ensure satisfactory 'damping' of vibrations at the 'free' end of the crankshaft. Torsional failure generally involves fracture in the areas of oil hole breakout with the journal. Smooth blending and absence of any damage is, therefore, essential.

The above information is intended as a general guide, being based on the writer's experience over an extended period of time. It must be emphasised, however, that, particularly in the case of modern engines, where the manufacturer's data is available, such information must be used in preference to that contained in this article.



LINKUP

- Reader to reader service • help
- queries
- wants
- small sales
- & its all free!

WANTED

* Anthony Walton of 62 Kingsmead Road, Tulse Hill, London SW2 3JG (Tel. 0181-674-9159) will pay a fair price for a 'Webber' 2in. x 1in. Croblox true square and is prepared to negotiate for Croblox set of angle gauges (or any individuals). Would consider same in tungsten carbide instead.

* Wanted: A No. 13 3/4in. Adept hand shaper in good condition; also some parts for a 10L South Bend lathe. Tom Thomas. 01580 860366.

* I need a Handbook, Maintenance Manual, lists, accessories for a Boxford C lathe. Costs reimbursed. P.G. Sheaf, 'Orchards' School Lane, Easton, Woodbridge, Suffolk. IP13 0ES. Tel. 01728 747427 or Fax 01728 747663.

* Wanted for Schaublin 12 Mill:- Operators Handbook, spare parts list, sales brochure and any other info. Originals preferred but photocopies O.K. as second choice. Any expenses willingly reimbursed. I would also like to contact any other owner of a Schaublin 12 Mill. I have a Schaublin 13 sales brochure which I would be willing to photocopy for any owner of one of these machines. R.F. Jettner, C/- Houghton P.O., South Australia 5131

* I would like to purchase or borrow for photocopying an operators manual for the Harrison 600 Series 30in. x 8in. H & V Milling Machine. Any expenses willingly reimbursed. D.M. Cockerton, 'Ferndene', Big Lane, Clarbrough, nr. Retford, Notts. DN22 9LT. Tel. 01777 704582

* Does anyone have any information on the J. A. Barnes lathe, thought to be of American manufacture and marketed by Melhuish, Sons & Co. of Fetter Lane, London E.C.7 Particular information required:- Taper in Headstock spindle and details of full complement of change wheels. J.S. Midwinter, 485 Coventry Road, Hinckley, Leics. LE10 0NF.

* For Churchill Cub Lathe. Wanted:- 1. Manual to borrow, photocopy and return. 2. Check back plate or dimensions thereof. 3. How many and what diameter steel balls does the clutch mechanism require? 4. Spare clutch and brake friction lining material. Michael Shaw. 33 Oakland Drive, Dawlish, Devon. EX7 9RW. Tel. (Day) 01392 410979 (Night) 01626 862980

* Can anyone provide information on any literature (textbooks, manuals, brochures etc.) which describe the theory, construction and operation of pantograph milling machines? Details of titles, authors and/or publishers would be appreciated. Ian Manning, 26 Gathorne Road, Southville, Bristol. BS3 1LU

FOR SALE

* Three assorted cross slides. One very, very large. One with vice. The lot £40.00 or will split. 1/4 H.P. motor £10.00. (Blackpool) Tel. 01263 354478
Adeock & Shipley 1ES and 2ER horizontal milling machine Sales and Specification brochure. £4.50 each. Operating instruction for Jones & Shipman precision grinder 1300 Range. 1957 book. £8.00 Pratt Burnerd 160mm 3 jaw chuck. External jaws only. £33.00 Tel. 01453 843946

A REMINDER TO THE USERS OF OUR LINK UP FACILITY

* A number of readers have mentioned that they have sent material in response to requests in this feature and have received no acknowledgement (in one case even after a follow-up letter). If you do receive items as a result of an appeal in Link Up, please let the sender know that it has arrived safely.



FIRST STEPS USEFUL TOOLS

The recent Reader Survey encouraged us not to forget the readers who are just establishing home workshops and would perhaps appreciate some simpler tasks which would help them to develop their engineering skills. We therefore asked Edmund Scott to reach into his tool cabinet and into his memory to bring us a few of the items he made in his early days in the trade.

As those who have served an apprenticeship will know, one usually has the opportunity to make some of the more simple tools which are likely to come in useful at a later date. In my case, the first nine months of the five years were spent in the basic training workshops, getting to know the fundamentals of hand and machine work. The exercise pieces which had to be completed at this time were mainly aimed at making these useful items. Interestingly enough, when my youngest son went through the same training school, exactly 30 years later, the test pieces were still the same, but the drawings had been metricated.

The first few weeks were spent 'on the benches', in the care of a very old craftsman who could work wonders with hacksaw, file and scraper. In reality a kindly old gent, he could get understandably tetchy at some of our youthful pranks, like smearing engineer's blue under the handle of his drawer! The first item to be made had a very limited potential for later use, as it was merely a one inch gap gauge, cut and filed from $\frac{3}{16}$ in. thick steel. It did, however teach one the basics of filing, as the two pieces had to fit together perfectly, with no gaps apparent when the assembly was put over a light box. The instructor was well aware of the trick of smearing the mating faces with oil, as he would wipe them perfectly clean before testing them.

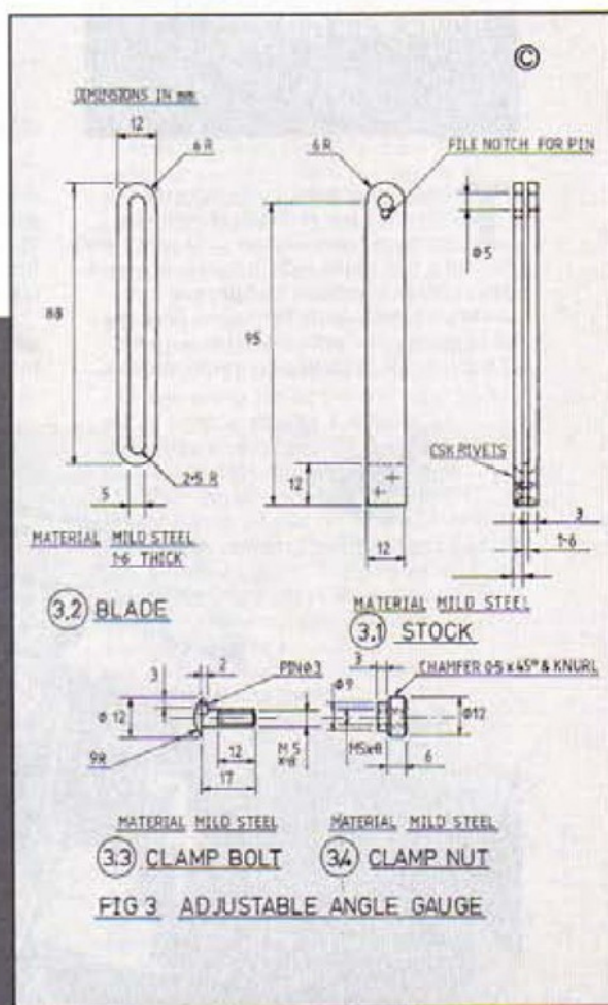
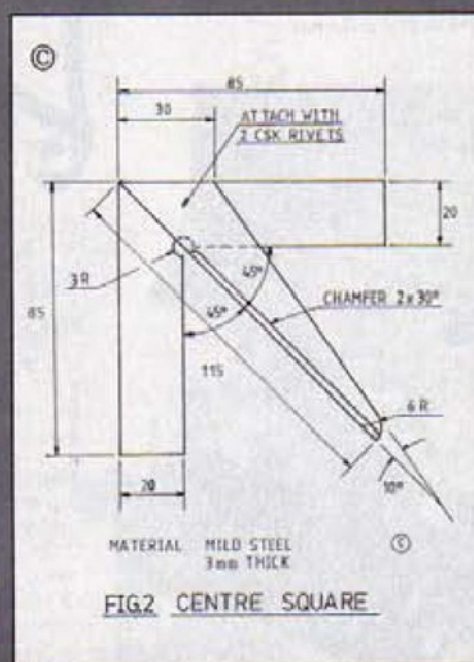
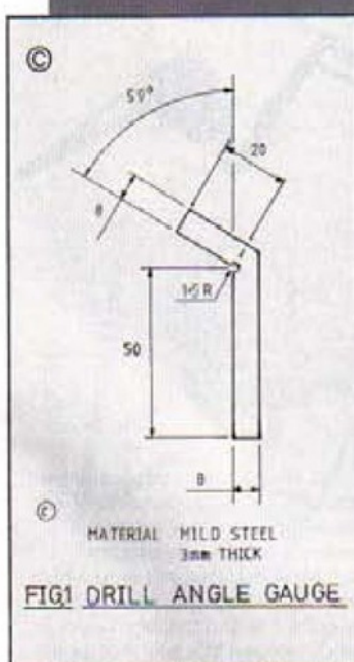
The next items, which were all to do with angles, were potentially of more use, even though they were still only sawing and filing exercises. The first shown here is a drill angle gauge (Fig. 1), useful a few weeks later when we were shown the rudiments of drill re-sharpening. This one is for a standard 118deg. drill point, but others can be made easily to taste. A refinement would be to engrave a linear scale up the angled arm to assist in getting the lip lengths equal, but our skills were not that advanced when these were made.

Next came a centre square (Fig.2) which, for anyone not familiar with the device, is used to establish the position of the centre of a round bar by defining two diameters from different angular positions round the circumference.

It consists of two pieces which are screwed then riveted together in a precise relationship, so that the blade is exactly at 45deg. to the arms, on a line passing through their apex.

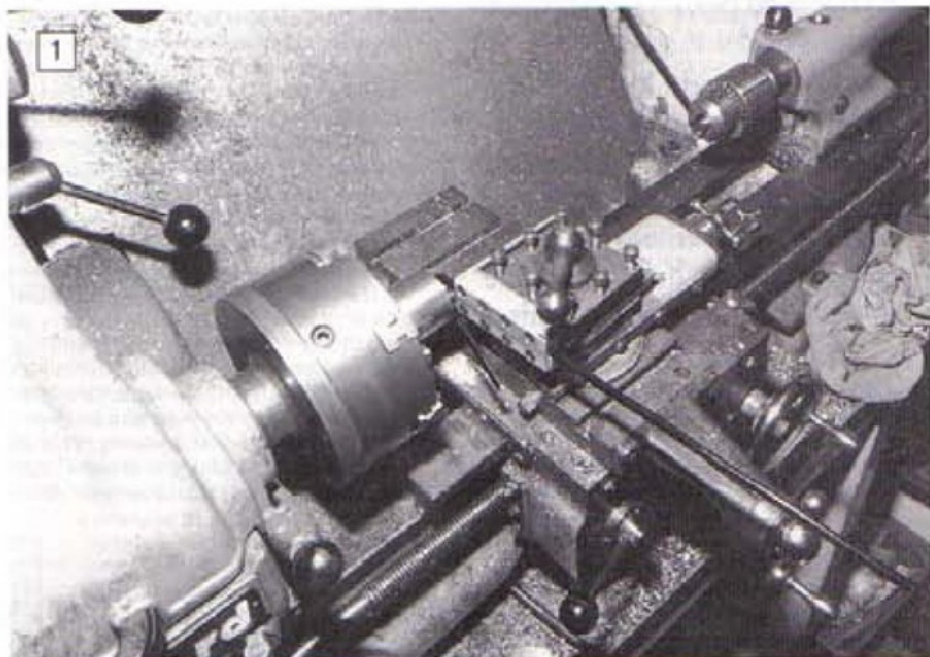
The third gauge took our skills a little further, as it involved a little turning, threading and knurling. This adjustable angle gauge (Fig.3) has proved invaluable over the years, being particularly useful for transferring angles when making mating parts. The thing to remember is that the side faces of both the stock and the blade must be parallel if this tool is to be accurate. When making the turned parts, the hole for the stop peg in the threaded pivot/clamp screw was drilled from the head end and the short peg pressed in before radiusing the head.

These items could all have been purchased for a few pounds, but there is much more satisfaction gained from having made them and every time I use one of them, pleasant memories are not far away. I must delve into the tool cabinet and find one or two more.



COILS FOR A NOVEL APPLICATION

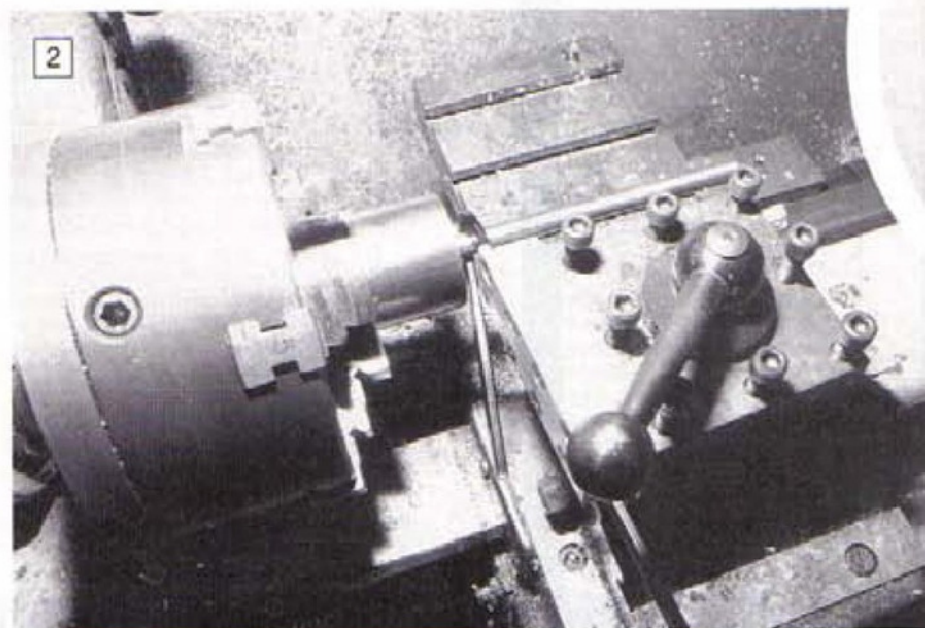
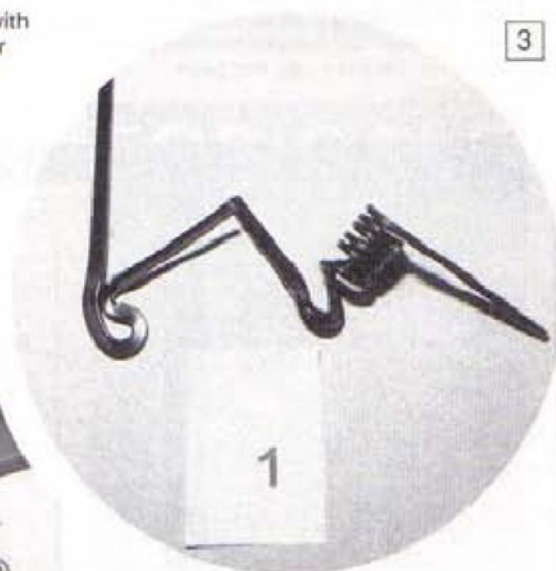
Edward T. Haas of Goleta, California needed some unusual copper coils for some intriguing experimental work. In this short article he explains how he went about winding them and concludes with a plea for help. We shall be interested to hear how future tests go!



The photographs show some of the attempts I have made at winding some unusual copper coils. With the help of a few of the lads in our club, I have managed to construct a single-coil electromagnetic launcher, using 20 turns of 12 gauge domestic insulated wire for the drive coil. With this common material,

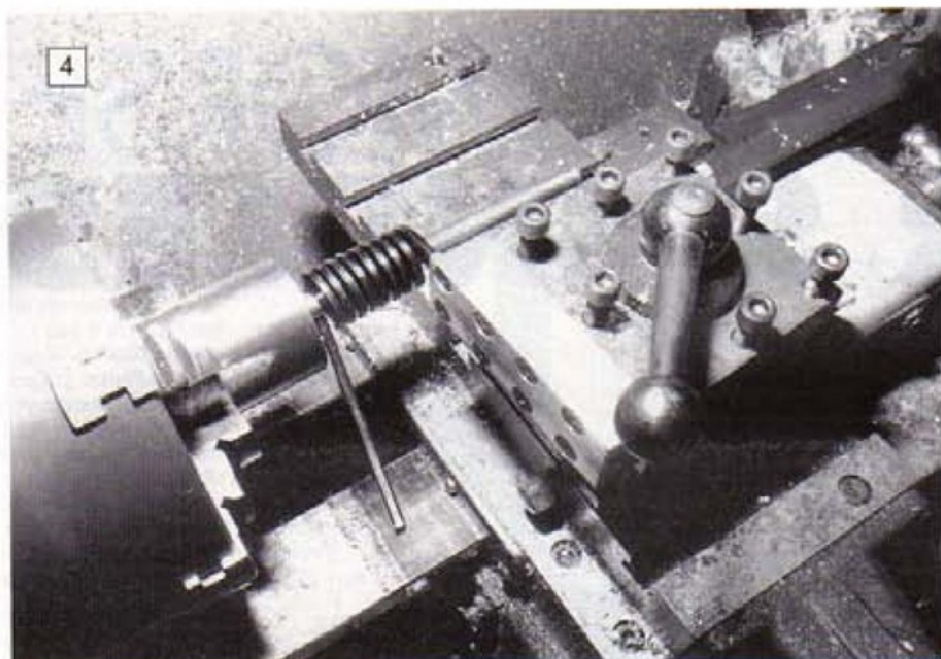
we achieved an acceleration of 40g with a 14.5 gram payload (a $\frac{1}{4}$ in. diameter stub drill), shot down a barrel made from an old fibreglass arrow shaft (carbon fibre will not do).

In an effort to evolve better coil designs quickly, I built a simple jig to wind wires of different



diameters. The photographs show the set-up and some of the results (successful and not so successful). The most extreme example was a $\frac{1}{8} \times \frac{1}{4}$ in. rectangular cross-section insulated magnet wire which it easily handled. To align the wire to be wound into coils, I feed it through a slot in a 'feeder box' clamped in a tool holder on the compound slide of the lathe.

Photo 1 is a long shot showing the



relative position of the feeder box in a tool holder, with wire inserted, ready for power to be engaged at the lowest possible speed. A Myford lathe is ideal for this operation, as it will run down to 30 rpm which, when making a 10 turn coil, is still fast enough to be scary! The second advantage of the Myford is that the chuck's rotation may be stopped instantly by disengaging belt tension, rather than by switching off the motor. If feasible, a hand crank should be used instead of power, to obtain uniform slow rotation of the winding mandrel. A length of wire (in the photos it's the $\frac{1}{8} \times \frac{1}{4}$ in. magnet wire) has been cut to the length required for the coil and fed through the feeder box (which is clamped in a 4-way tool holder).

To begin, the driving pin is at the 12 o'clock position, which allows wire to be hand fed between it and the winding mandrel. Next, the chuck is rotated backwards by hand, until the protruding short end of the wire swings around and almost touches the bottom of the feeder box. At this point I grab that short end of the wire and bend it to the left, so that it will not collide with the feeder box once the lathe motor is turned on (**Photo 2**).

Photo 3 shows what can happen if this step is not taken: the 'coils' on the left are testimony to what can go wrong!

Photo 4 depicts a fully wound coil. Several things are worth mentioning at this point:

Note that the feeder box is angled slightly, so that it is not square when looking down at it from above. It is fixed about 5 deg. counter-clockwise from the perpendicular, so that the wire is fed parallel to the helix angle of the coil, to prevent any undue stress upon the wire and to minimise the chance that the insulated coating might crack or scrape off.

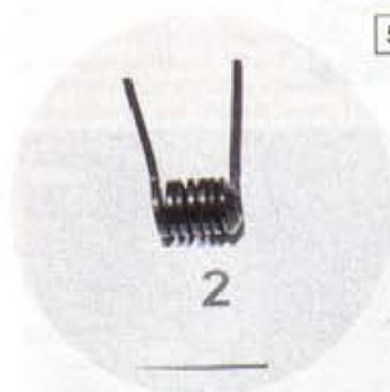
Note also that, since the material I am winding is copper, there is virtually no springback, so a 10 turn coil needs only be wrapped exactly 10 turns: no allowance is necessary as the material is dead soft and takes a set immediately the coil is wound.

Since it's pretty much impossible to set a feed rate for the carriage which will correspond with the rate of deposition of coil wraps, it's necessary to hand-crank the carriage along the bed of the lathe from left to right. In **Photo 5**, coil No.2 illustrates a coning which occurs if the carriage is not cranked fast enough.

When the coil has been made, the feeder box is backed off of the tail end of the wire by cranking out the cross feed on the compound slide. The coil can then be run off the mandrel to the right and the process can be repeated immediately for as many coils as are needed.

Coil No.4 illustrates the results of an uneven cranking speed. Coil No.5 illustrates what happens when all goes right.

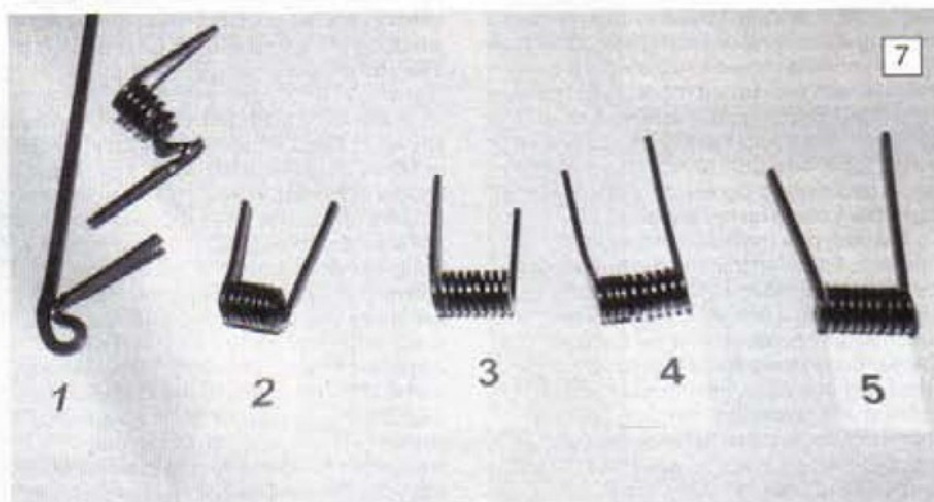
Much to my surprise, this lash up has worked flawlessly and I would recommend it to your readers if anyone has similar needs. The coils were designed to improve the electromagnetic launcher, but subsequent measurements have shown their internal resistance to be so low that a new problem has emerged: my switches keep blowing up! Does anybody know where I can get one that will handle 50 volts and 100,000 amps in one millisecond?



5

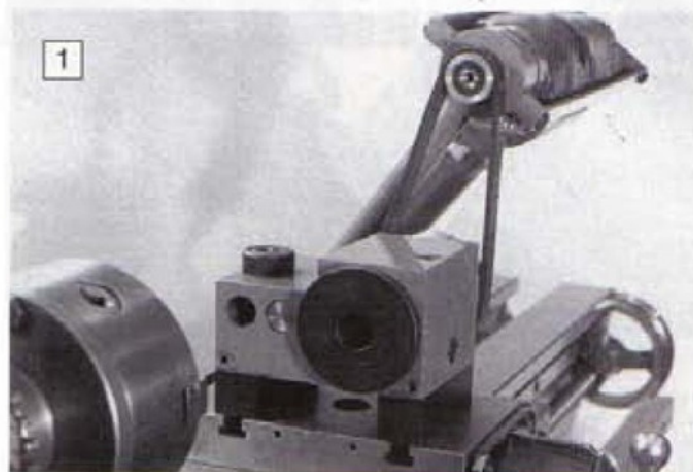


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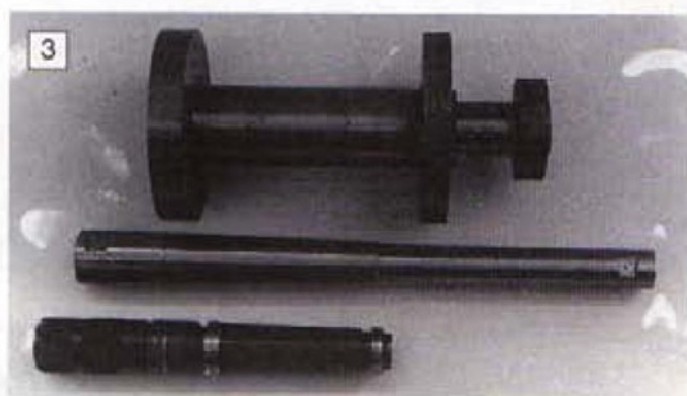
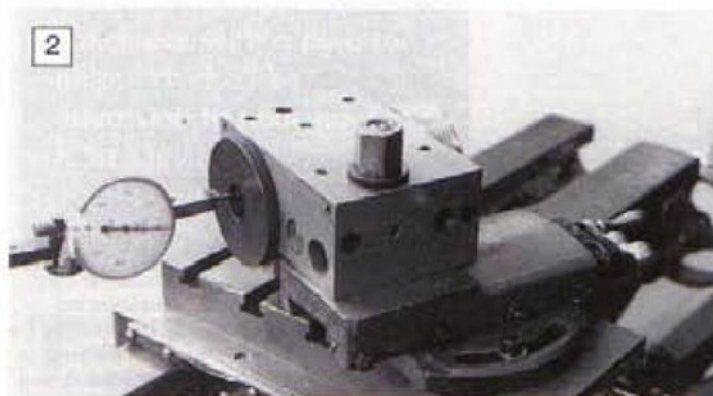


CONCENTRIC MORSE TAPER SPINDLES

Many of the pieces of equipment described in this magazine rely upon a Morse Taper shank or socket for their accuracy. David Dew of King's Lynn describes the method he used to create the taper in SPAM, a versatile milling, drilling and grinding spindle.



1: The No.2 Morse Taper mandrel takes a variety of tooling.
2: Checking concentricity of the socket. This photo shows SPAM's versatility.
3: The gauge, the turning mandrel and the partly finished spindle.



These notes describe fundamentally sound methods which will I hope, produce accurate and concentric Morse tapers, on normal home workshop equipment.

At a recent club meeting I was giving the 'chat'. This was describing SPAM, a self-powered mill/drill/grind mandrel for a Myford. SPAM was still all neat and tidy, having not long returned from Olympia. Of course the discussion wandered as club chats do, and we spent a fair time talking about improvised soft jaws; but there was a lot of interest and discussion about the method I had used to obtain the concentricity of the bore - better than would indicate on a 0.0001in. DTI.

Figure 1 shows the layout of the mandrel. It is carried in 2 taper roller bearings (32005) with drive flats and a thread at the tail end. The front does not carry a lathe nose thread as it was desired to reduce the overhang for milling (a 2 MT/chuck adapter is used when required.) The body is an iron casting and the bearings can be made a light interference fit by boring right through and lapping the 47mm diameter. A truly square spacer completes the housing

of an easy to make precise bearing housing.

I made a similar unit in 1981, so I had some practice. That was change-gear driven, and on a much larger base that made it not very convenient to set-up. In particular it was not very good at 'across-the-bed' type set-ups. Following this, a succession of designs and a wooden mock-up were made and evaluated. A unique (I believe) arrangement of using either long or short 'parallels' makes it very versatile indeed to position. I am very pleased with the current model, which is Poly-V belt driven with 14 speeds from 230 to 10,500 rpm using 4 pulleys and a two speed (gear-box) drill. Most of these speeds are in geometric progression. Both machines have been made on my ancient ML7.

Returning to the mandrel/bearing problem, I decided that the method would be to put the mandrel blank, with the female taper cut, onto a centred male taper mandrel and machine between centres. It would appear that in the past writers have described in articles, inferior methods of holding and producing mandrels. Club members verified that in following these, inevitable errors creep in, which are difficult or impossible to eradicate.

The gauge

It may seem long-winded but this is how I did SPAM. I first produced a 2 MT setting-up and checking gauge. The taper is 0.04995 inches per inch for No.2. The length of the socket hole is $2\frac{39}{64}$ in., the large end of the socket is 0.700in. diameter. The text books seem to say 'no error but make the socket small at the big end and the plug small at the little end if there is any!'

A standard method of checking tapers is shown in **Fig.2**. I have copied this principle as far as possible in the lathe. The gauge is shown in **Photo 2**. The main features are to work on centres; then to make 2 faces at an exact distance apart (2in. in this case.). Rough down and relieve the section between the rings, refining the taper setting as you go (difference in reading on sharp edge is 0.0999in. for 2 MT). Both edges are finally cut to size, independently, to this difference. These final independent cuts allow great accuracy - the well oiled smooth file can also come into play! You are aiming of course for the difference between the dimensions not the size itself,

that allows for several goes!

You have now got a very accurate gauge for testing internal tapers - one which will ignore waisting and barrelling. A line at 0.700in. dia. can be added. More important, the gauge can be set between centres and either the top or taper turning slides can be set from it, using the DTI (It is of no use unfortunately for off-setting the tailstock, due to different lengths between the centres.)

I use a similar method to that above for checking tapers made with an offset tailstock, (well, the boring head with a centre, fitted in the tailstock!). Using a micrometer with sharp edges to the anvils one can measure the two diameters. The length between can be traversed via the leadscrew (because of the angle, the movement should be 2.0006in.). The micrometer is supported against something in the toolpost.

The internal taper

These I admit are not 'textbook' methods - I could not find any! They are methods I have worked out to solve the particular problems I had.

A taper turning attachment is very desirable for the internal taper. The genuine article used to cost an arm and leg for something not often used. However you could....

- 1) Find a secondhand one. I was very lucky and offered most of one for a fraction of the original cost.
- 2) Look at Myford's new lower cost attachment.
- 3) Consider Hemingway's kit.
- 4) Make your own.

If you still don't have one then you have to use the top-slide, which is more difficult as it has only just enough travel on the Myford 7 and you can't use auto traverse. The ML10 has just too little movement to make a full length 2MT (but shortened tapers still work.). Either can be set from the gauge which can then obviously be used to see what's slipped, hopefully before size is reached. The line will tell you when correct diameter has been achieved. I feel very confident using this method.

The taper mandrel

This is a most obvious device, shown in **Fig. 3** and the photograph. Just make sure there is plenty of 'tail' at both ends for a carrier. Tap the mating tapers together and now you can turn the bearing diameters etc. etc. between centres, knowing you are as true as possible to the bore.

I turn the bearing diameters independently, leaving each 0.001in. over size, and then use a Dural lap to bring them to the correct fit. In this case that is a slight interference on the front race and a close sliding fit on the rear, as this is the adjustable element.

The result of all this will give without doubt a truly running mandrel - an unshaking needle on a 0.0001in. DTI set into the bore. However, it is all a bit long winded, and I do hope that if SPAM ever becomes available as a kit, then it will include both the internal and external tapers cut already.

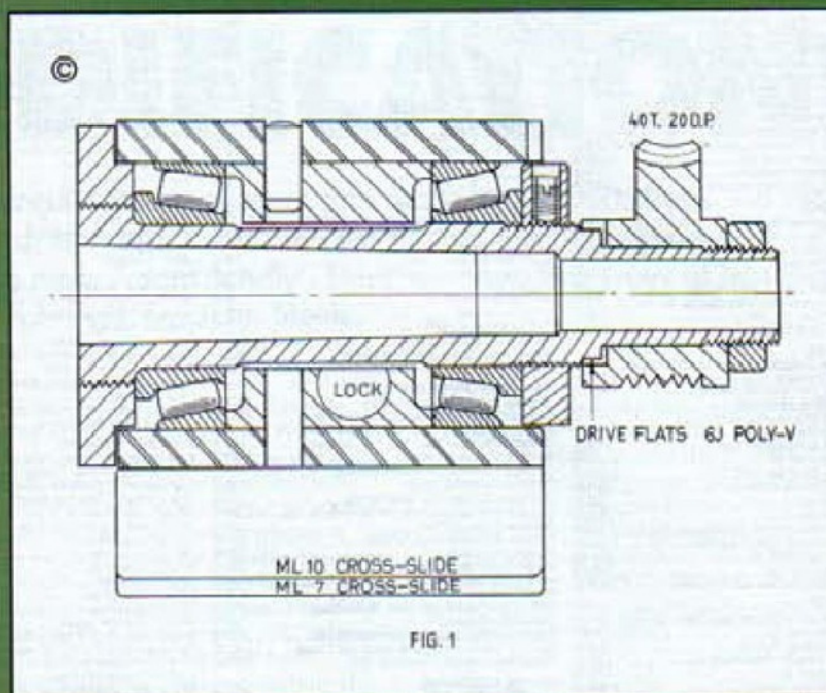


FIG. 1

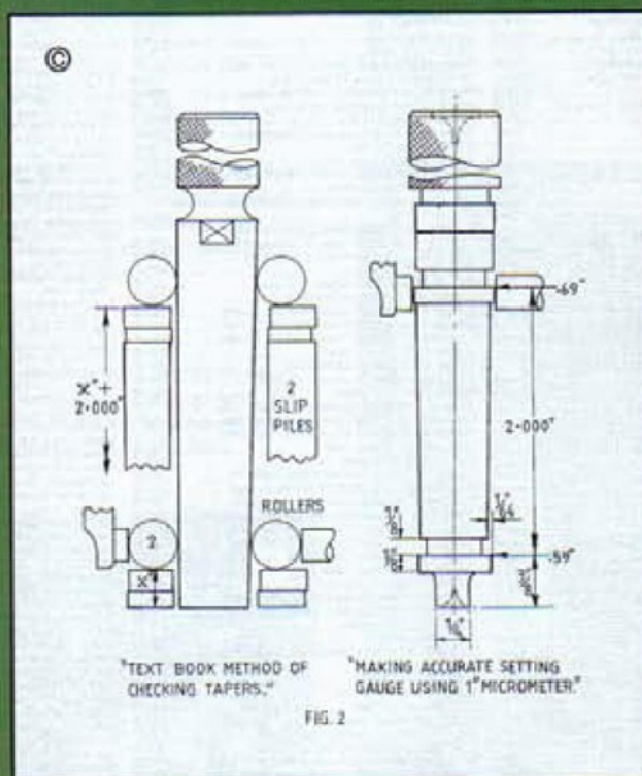


FIG. 2

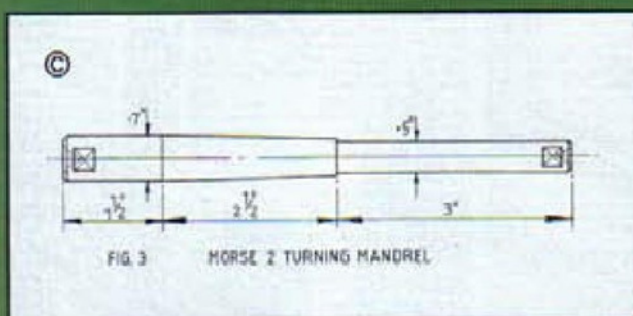


FIG. 3

MORSE 2 TURNING MANDREL

LATHES

Bedford CUD 12" x 22" 3ph. Fully Tocked £1200.00
 Bedford CUD 12" x 22" Plain Lathe, 3ph £600.00
 Bedford CUD 4 1/2" x 18" 3ph. Tocked £300.00
 Bedford CUD 4 1/2" x 18" 3ph. Variable Speed Drive, Tocked £375.00
 Harrison M200 Lathe & Tooling, Immaculate, 3 ph available £3250.00
 Harrison M200 4 1/2" x 25" Centre Lathe, Tocked, 1ph £2850.00
 Harrison 140 5 1/2" x 25" Cap. Bed Centre Lathe, Tocked, 3ph £1750.00
 Harrison 15 9" x 25" Lathe & Tooling, inc. Taper Turning attach £1000.00
 Harrison 15 9" x 25" Lathe & Tooling £750.00
 Harrison 15 9" x 25" Lathe & Tooling, Single Phase £1000.00
 Harrison 165 Straight Bed Lathe with Copying, Tocked, 3ph £1000.00
 Colchester Master 15 1/2" x 25" Cap Bed Lathe, Tocked, 3ph £2850.00
 Colchester Master 15 1/2" x 25" Cap Bed Lathe, Tocked £1450.00
 Colchester Bantam 5" x 20" Lathe Tocked, 3ph £550.00
 Colchester Student 6" x 25" Centre Lathe, 3ph £850.00
 Pulis Lathe, Cabinet Stand, Cross and Compound Slides, Cut Off Side, Capstan At, Lower Cap Tailstock, 150 Collets, 3 phase £2000.00
 Smith and Brown 1024 Toolroom Lathe, Tocked, DPCO 3 phase £1250.00
 Hirst Conquest Centre Lathe, 3ph £1000.00
 Myford M10 Woodlathe & Accessories £275.00
 Raglan Liliput Variable Speed Lathe, 1ph £400.00

DRILLING MACHINES

Starline EPI Geared Hand Drill, 3MT, 75-2800 rpm, 3ph £850.00
 Hirst Progress 40 Geared Hand Drill Machine, 3ph £800.00
 Arbogast Plan Drilling Machine, 3 phase £325.00
 Herbert Plan Drill 440-2500 rpm, 3ph, 1MT £250.00
 Herbert Plan Drill 2000-5500 rpm, 3ph £175.00
 Starline Mercury Mark 2 Bench Drilling Machine £175.00
 Promer 1" Cap, 5 Speed Bench Drilling Machine, 1ph, New £450.00
 Oxa Bench Drill 1" Cap, 1ph, New £175.00
 Maddington 1" Cap Bench Drill, 3ph £175.00

MILLING MACHINES

Arbogast and Shipley 25" Horizontal Vertical Mill, 40-INT Spindle, Well Tocked, DPCO, 3 phase £2000.00
 Redgrop Series 1 2 HP Turret Mill, DPCO, 3ph £1000.00
 Redgrop Turret Milling Machine, 3ph £1000.00
 Elcot 1100 Vertical Milling Machine, 40-INT £1250.00
 Elcot V1 Vertical Mill, 3ph £800.00
 Elcot P1 Horizontal Milling Machine, 3ph £1000.00
 Bedford V100 Vertical Mill, 3ph £1450.00
 BGA Mill Jig Bore, Bench Top, VGC £1000.00
 Myford K2-V-M-C Turret Mill, Hi Spindle, 1ph £500.00
 Raglan Vertical Mill, 3ph £500.00
 Raglan Mill Drill, 1 phase £550.00
 Tom Senior MT Horizontal/Vertical Milling Machine, 3ph £1000.00
 Tom Senior MT Horizontal/Vertical Milling Machine, 1ph £1000.00
 Tom Senior MT Horizontal Mill, 3ph £500.00
 Grainger Engineer with Type £450.00
 Archdale Vertical Milling Machine, 40-INT, 3 phase £450.00

POWER HACKSAWS

Oxley Mec 250 Circular Cut Off Saw, Stand, Blade, 1ph, NEW £300.00
 Galt 7 1/2" Power Hack Saw, 3ph £250.00
 Rapido 8" Power Hack Saw, 3 phase £250.00
 Source Vact 14" Band Saw, Fixed Winder, 3ph £550.00
 Sinter 180" Band Saw, 3ph £750.00
 Forte Horizontal Bandsaw, 3 phase £1650.00
 Maddington 25" Throat, Floor Standing Flat Saw, 3ph, VGC £275.00

GRINDERS, UNISERS, POLISHERS

Kearl D10 Port Grinder, 3ph £200.00
 Victory Horizontal 18" Shapegrinder, 3 phase £250.00
 Victory Horizontal 18" Shapegrinder, 3 phase £250.00
 Bantam (Planer) Tool & Cutter Grinder, Tocked, Immaculate £1250.00
 Jackson M8 Tool & Cutter Grinder, Tocked, 3ph £750.00
 Clarkson Tool & Cutter Grinder (Bantam Machine), 3ph £750.00
 Auto ARGE Tool & Cutter Grinder, Very Well Tocked £1500.00
 Vicer Tool and Cutter Grinder, Tocked, 3ph £750.00
 Union Tool and Cutter Grinder, Cabinet Stand, Tocking, 3ph £750.00
 Wolf 6" Bench Grinder, 3ph £350.00
 Wolf 6" Bench Grinder, 3ph £350.00
 Delta 6" Bench Grinder, 1ph £350.00
 Tinned Bench Lapping Grinder, 1ph £75.00
 Wolf 10" Bench Grinder, New, 1ph £150.00
 Victory Double Ended Polisher, 3 phase £150.00
 Chester Model 108 Dnd Grinder £580.00

SHAPERS

Bedford 8" Shaper, 3ph, Cabinet Stand, Immaculate £500.00
 Bedford 8" Shaper, 1ph, Cabinet Stand £380.00
 Elcot 10M Shaper, 3ph £500.00

BORFORD SPARES AND TOOLING

Change Gears (and 4 Southbends)
 10T 12T 15T 20T 25T 30T 35T 40T 45T 50T 55T 60T 65T 70T 75T 80T 85T 90T 95T 100T 110T 120T 130T 140T 150T 160T 170T 180T 190T 200T 220T 240T 260T 280T 300T 320T 340T 360T 380T 400T 420T 440T 460T 480T 500T 520T 540T 560T 580T 600T 620T 640T 660T 680T 700T 720T 740T 760T 780T 800T 820T 840T 860T 880T 900T 920T 940T 960T 980T 1000T 1100T 1200T 1300T 1400T 1500T 1600T 1700T 1800T 1900T 2000T 2200T 2400T 2600T 2800T 3000T 3200T 3400T 3600T 3800T 4000T 4200T 4400T 4600T 4800T 5000T 5200T 5400T 5600T 5800T 6000T 6200T 6400T 6600T 6800T 7000T 7200T 7400T 7600T 7800T 8000T 8200T 8400T 8600T 8800T 9000T 9200T 9400T 9600T 9800T 10000T 11000T 12000T 13000T 14000T 15000T 16000T 17000T 18000T 19000T 20000T 22000T 24000T 26000T 28000T 30000T 32000T 34000T 36000T 38000T 40000T 42000T 44000T 46000T 48000T 50000T 52000T 54000T 56000T 58000T 60000T 62000T 64000T 66000T 68000T 70000T 72000T 74000T 76000T 78000T 80000T 82000T 84000T 86000T 88000T 90000T 92000T 94000T 96000T 98000T 100000T 110000T 120000T 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MILL/DRILL MODIFICATIONS

The Mill/Drill is becoming a feature of more and more home workshops. No matter how good the original design, our inventive contributors are finding ways of making these machines more 'user friendly'. Here we have two ways of tackling the same job, the first coming from John Steele.

The Hobbymat BFE 65 milling machine featured in my earlier articles was proving to be a very useful and well made machine. Its ability to take on a wide range of jobs has been evident from the articles published in recent issues of *MEV*. However, like all machines, even the most expensive, some minor improvements are often found to be worthwhile. These may be due to some limitation in the machine itself, or some peculiarity of the particular application. In this case the latter is the reason.

One very small modification which is an instance of this situation, relates to the cursor line for reading the down feed movement. As the workshop is small, every inch counts and, as a result, the machine has been placed as near to the left hand end of the bench as is practical. One effect of this action is that the cursor line, which is on the left hand side, is very difficult to see, made doubly so because it tends to be in shadow. The problem was easily overcome by removal of the bearing block which carries the line and making another line in a more suitable position on the right hand side.

The need to conserve space

Of less importance, but needing more work to overcome, was the room taken up by the head clamping screws, combined with their slightly inaccessible position. Again, due to the limited size of the workshop, the depth of the bench on which the machine has been placed has been kept to a minimum. In fact, due to making the bench prior to receiving the

machine, it really is too shallow, primarily as a result of the details given for the machine being inadequate.

Observant readers may have noticed that both the milling machine and lathe have been seen in use, without being fixed to the bench, as is evident in **photo 1**. The reason for this is two fold; firstly, the need to modify the head clamping screws to make the machine less space consuming delayed the final positioning, and secondly to delay the actual fixing until I was confident about the final positioning of both machines.

Photograph 1 shows that the original head fixing screws are almost totally obscured, one being just visible below the casting that moves up and down the column. Of even more importance is the fact that due to being short and behind the

casting, they also have to angle away from the casting to make easy access for the hand to operate them. This can be seen in **photo 2** which shows the screws removed from the head. The need was to make them less space consuming, in terms of depth, a task most easily accomplished by making them longer, so that they could be operated from in front. In this case they can be quite close fitting to the column casting.

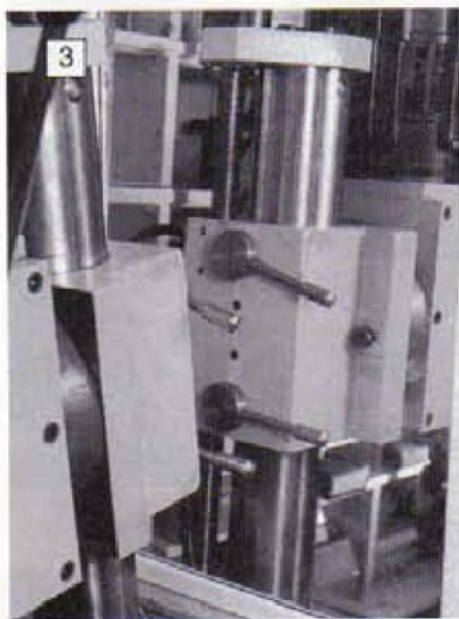
Essential dimensions

Having given the reasoning, making the parts requires little explanation; neither are drawings included, as **photos 3 & 4** should give sufficient detail. There have been design changes in this area, so if

1: The head clamping screws are behind the casting which moves up and down the column and are somewhat inaccessible. They also project back and take up valuable space.

2: The original screws.

3: The new longer screws fit much more closely to the casting, taking up less than 10mm in depth. Not two machines, but one taken with the aid of a mirror.

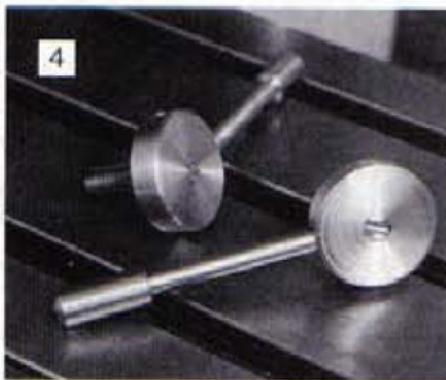


QUICK TIP

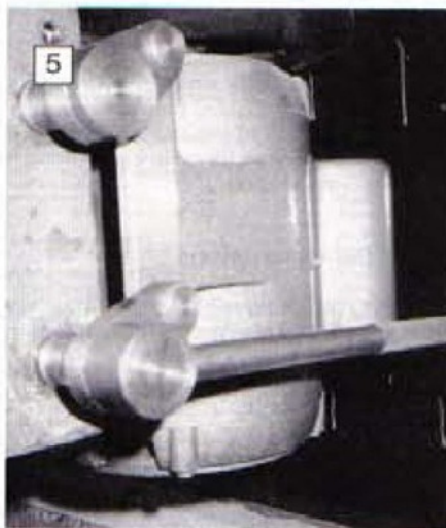
Sorting small parts made easy.

Searching through a collection of mixed items such as nuts, bolts and washers is less daunting if they are first decanted into a short length of plastic guttering (preferably white). Move the 'unwanted' along to one end, then pour those to be returned to 'stock' back into their container in one go.

Robert Vincent



4: The new screws. The original studs were used and shortened, hence the slot which is half the hole for the pin which was used to secure the original handle.



5 & 6: Two views of the modification to the Warco mill/drill.

QUICK TIP

Plans available

A simple to make accurate cross drilling jig for making accurate and repeatable cross drillings in small diameter shafts
By Alan Bourne (Described in M.E. Vol. 174)

Continue next page ►

dimensions were given they may not be appropriate in all cases. The essential consideration is that the diameter of the central boss of one screw and the length of the arm on the other are such that they permit the screws to rotate fully for initial assembly, or subsequent dismantling. In the case of the modified machine the dimensions are nominally 32mm for the diameter of the boss and 75mm for the length of the arm, this dimension taken from the centre line of the screw.

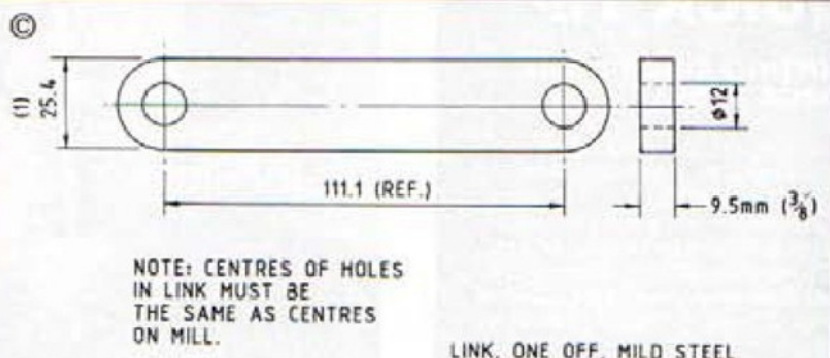
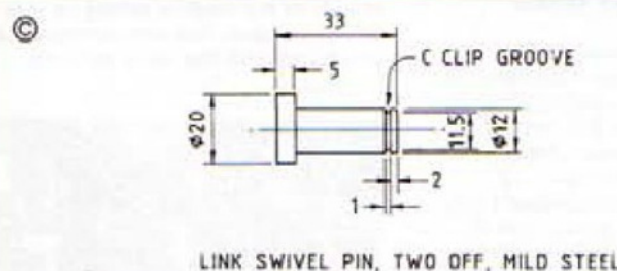
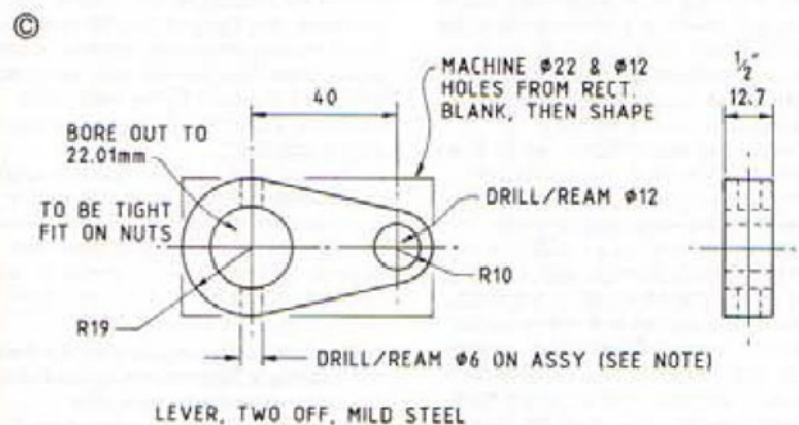
The new screws use the studs taken from the original and the large central boss is secured using a cross drilled hole with a suitable pin, as was the original. In fact, the slot apparent in the end of the stud seen in photo 4 is where the saw cut went through the hole for the original pin when it was shortened.

A rubber washer between casting and central boss ensures that the handle still remains accessible, rather than falling

down when the clamping pressure is released. Only some 30 to 40deg. movement is required to release the head. Of course it is essential that the central boss is drilled to ensure the arm sits in an acceptable position when clamped, say 10 to 20 degrees above horizontal. After fitting and marking with the drilling position for the arm, I stamped the bosses "T" top and "B" bottom respectively, so as to ensure they returned to the correct position. The arms were retained in the central boss using a suitable adhesive.

A worthwhile modification

Even where space is not a problem, this simple little modification would appear to me to be worthwhile, as it does make operating the clamps considerably more acceptable.

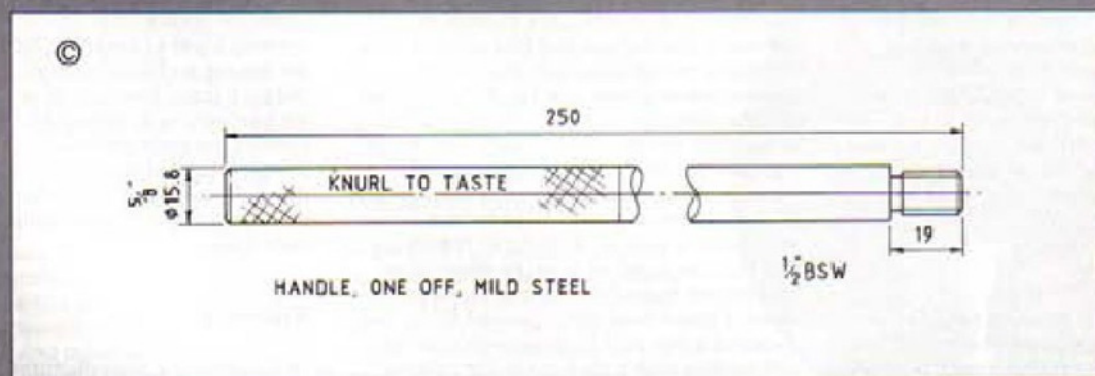


Another modification for the Mill/Drill?
Yes, definitely yes!

I will only mention a couple of points, the first being the bolts. I found $\frac{1}{2}$ in. BSW quite suitable, as the pitch is sufficiently coarse to draw in to clamp with a 110 degree turn.

One item I nearly forgot. Your machine may have an adjustment screw for the

Sheet 1: General arrangement, parts required to make the jig, and associated scribing fence. Available from Plans Service, Nexus House, Boundary Way, Hemel Hempstead, Herts, HP2 7ST Tel. 01442 66551. Fax. 01442 66998



AN INTRODUCTION TO ENAMELLING METALS



Clock and instrument makers have, on occasions, the need to enamel dials and faces. The technique used is the same as that employed by jewellers and artists. Alan Jeeves gives us an insight into the materials and processes involved.

1. An enamelled clock face. 'Dial White' enamel is available for such jobs.

For well over 1000 years the techniques of fusing enduring coloured glazes onto metal bases have been held in high esteem by craftsmen who have, through the centuries, perfected this particular aspect of decorative metalwork. This art form is known as 'enamelling' and the glazes which produce the superb hard surface finishes are called enamels - the same material which was used to coat the surface of the old cast iron bath.

It is perfectly within the bounds of the small home workshop to originate first class pieces of work, regulated only by the type of equipment which is on hand. Even if only a small kiln is available, enamelled components can be made to form part of a much larger metal project and attached to it later. The popularity of the enamel butterfly brooch is indeed a testament to the quality of colour and detail which is attainable using these enamelling techniques. Even some types of paint have adopted the term 'enamel paint' in order to suggest a harder and more durable surface when dried, although these products are not, of course, enamels.

Base metals

Large commercial manufacturers of enamel work can make use of iron and aluminium as base metals by using special grades of enamel, but the amateur will be confined to the use of gold, silver and

copper and its alloys. Certain grades of steel may also be worked within the small workshop. Pure gold - 24 carat - is a soft metal which, because of its malleability, is easy to work. However, 18 carat gold is more generally used for enamelling work. It is somewhat harder, not as yellow and is, of course, less expensive. Whilst pure gold melts at a temperature of 1063deg. C, 18 carat gold melts at the much lower temperature of 905deg. C. During enamelling, gold can sustain repeated firings in the kiln.

Two types of silver are used, 'fine silver', which contains at least 999 parts per 1000 of pure silver and 'sterling silver', which has a minimum 925 parts of pure silver per 1000 parts (copper being the alloying metal). Silvers are normally 'keyed' or roughened up to assist the enamel to adhere to the surface and fine silver is very reflective, which enhances the use of translucent enamels upon it. Although fine silver withstands repeated firing, sterling silver does not do so as readily. Fine silver melts at 961.5deg. C, and sterling silver melts at 893deg. C.

A very popular metal base for the enameller is copper. Melting at 1083deg. C, this familiar material is easily obtainable and comes much cheaper than gold or silver. Copper tolerates repeated firing, but exposed areas (not covered with enamel) will oxidise with a dark scale-like coating, which must be removed after each subsequent firing. It can be got up very

bright before translucent enamels are applied to it, and this quality makes for very attractive work.

Another metal of similar popularity to copper is one of its alloys called 'gilding metal'. Composed of copper and zinc, the type of gilding metal which is most suitable for enamelling is a grade which has a zinc content of only 5% or so, and in any event should never contain in excess of 10% zinc for successful enamelling work. An alloy of this grade has a melting point of 1065deg. C, and lends itself well to work which requires up to 3 firings. Gilding metal is, obviously, especially suitable for gilding (after the enamelling has been completed).

We have already seen that certain grades of mild steel can be used as a base metal for enamelling. These grades have a melting point of around 1350deg. C. and do require surface preparation in order to obtain a good bond. Steel is not reflective for enamelling purposes and opaque colours are perhaps better for use with this metal. A special assortment of colours is normally available in smaller quantities which are produced particularly for use with steel.

Enamels

Enamels are manufactured. They are a type of glass and those which are suitable for fusing to metal are called 'jewellery



2. An example of commercial enamelling of yesteryear



3. A small kiln is required for firing the work

4. Fire precautions should be at hand

5. Stoning work under a running tap



enamels' or 'metal enamels'. The numerous different types made (varying in colour and quality) are loosely divided into three groups - transparents or translucents, opaques and opalescents. The second group, opaque enamels are produced in an extremely wide variety of colours and shades and are accountable for the magnificent dense glazes which are so revered. The opalescent enamels are available in a much smaller variety of colours and it is by the use of these that the iridescent lustres are achieved. The transparent enamels are sometimes colourless or alternatively, can be slightly tinted and allow the bright metallic surface to be clearly seen below the fired glaze. They can even be more generously tinted, allowing less light to pass through, resulting in the effect that only the very bright metal bases may be seen below.

The main constituent of all enamels is a composition of silica which is compounded with varying amounts of borax, potassium, salts of sodium and oxide of lead, which form a vitreous fondant called 'flux' (it is important to note that lead free fluxes are increasingly being made). In order to

obtain a colour, pigments must, of course, be added to the flux when it is being made, and these usually take the form of metallic oxides. Other minerals are added too, in order to enhance and create different degrees of opacity, and also to improve the translucency of the transparent colours. All these ingredients are then melted together in a furnace. The mixture is next poured out onto a cooling slab, or sometimes into a water bath, where it cools into small tablets of enamel. The tablets are then broken up into smaller pieces and these pieces are known as 'frit'.

Preparing Enamel

Enamel can also be supplied in powdered form, which means it has been crushed in a ball mill by the manufacturers, and is usually graded according to the mesh size system - 80 grit = 80 meshes per inch, 200 grit = 200 meshes per inch and so on. However, many

amateur enamellers purchase frit.

Clearly it will have to be pulverised into powder before use and a suitable method of doing so is in a hard porcelain mortar, crushing being



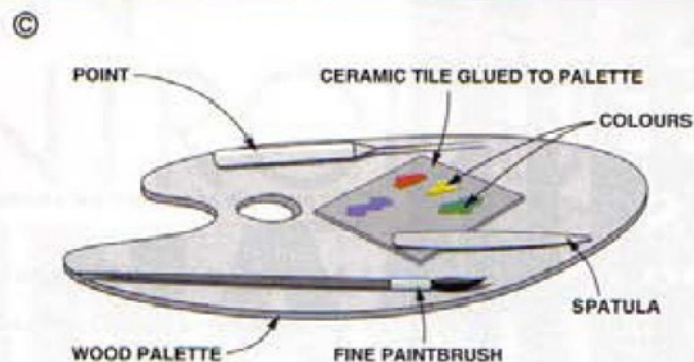


Fig.1. Title palette for mixing colours

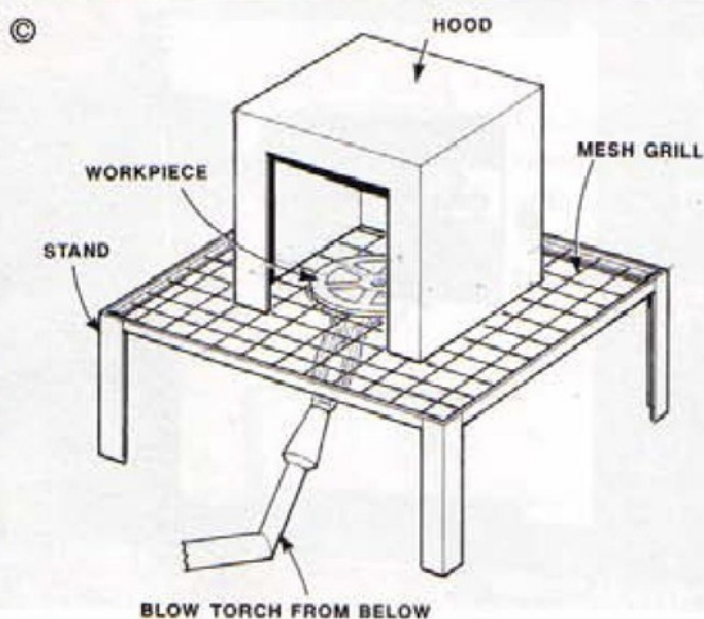


Fig.2. Firing hearth

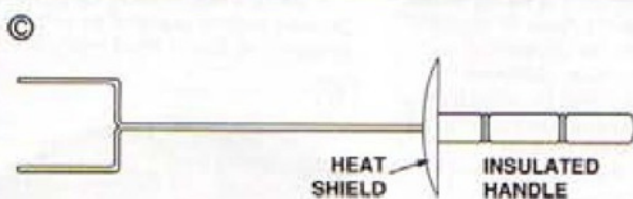


Fig.4. Firing fork



Fig.5. Draining paste in a tilted dish

Fig. 3 firing supports

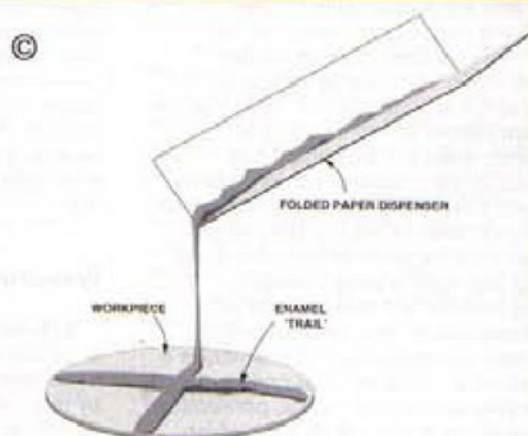
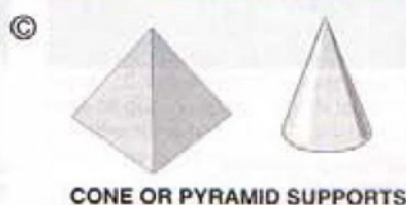
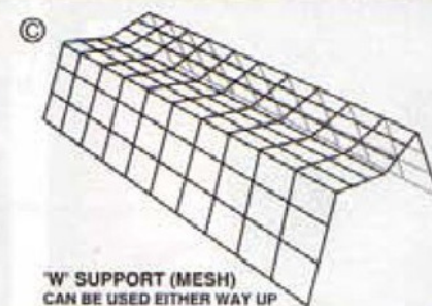
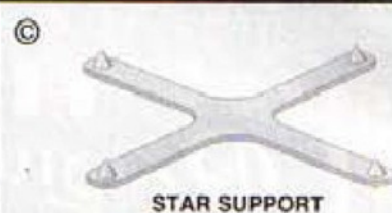


Fig.6. Enamel powder dispenser

carried out with a pestle. Before this can be done though, the frit will have to be broken up into smaller pieces of about the same size as peas; placing the frit in a cloth bag and then hitting with a hammer on a hard surface will do the trick.

The small pieces are placed in the bottom of the mortar, which is now half filled with water, the pieces being totally submerged. As the enamel is crushed and becomes finer, it clouds the water with dust, so this is poured off from time to time and replaced with fresh clean water. Prior to doing this the sides of the mortar are tapped with a wooden mallet, which settles the larger floating grains in the bottom. This is effectively washing the powder. Eventually the material reaches the required consistency, which will be very fine for opaque colours and not quite so fine for translucent. If the enamel is ground and washed immediately before use it will enhance the brilliance of the colours.

When the paste (as it now is) is ready, it should be transferred from the mortar into a receptacle with a lid. The lid serves two purposes, to keep the paste moist whilst other colours are being prepared and also to keep out dirt and dust. Small amounts of water can be added to the paste to counter evaporation whilst it is still moist, but if it starts to dry out, a hard surface will form and it will have to be re-ground and washed again before use.

Metallic oxides

The metallic oxides (or pigments) which are used for the colouring of enamels include copper - which produces the turquoise shades, green and sometimes red. Iron - for reddish/brown or green. Cobalt - for blue shades, Platinum for grey. Iridium - also for grey and black too. Nickel for brown. Manganese - for purple. Antimony - for yellow. Selenium - for pink or yellow. Gold - for pink, purple and opaque or translucent red. Chromium - for green/yellow and Tin - for the important opaque white. A calix has to be added to make opaque enamels, which is itself a powdery oxide (calcium oxide). Different metallic oxides can be mixed at this stage to produce different colours, but once the enamel has been made, that is its colour. It is not feasible to mix different colours of enamel to try to produce a different shade.

These metallic oxides may though, be bought as quite fine powders and can be prepared on a ceramic palette, applied to already enamelled work and re-fired to produce an 'overglaze'. Most of them can be mixed to produce different shades, although it will be found that certain ones cannot. They can, however, all be lightened by adding white (tin).

To prepare the powder for painting onto the work, it has to be mixed with a substance which will hold it in suspension during the painting procedure, but will dry off easily and not impede the firing or adversely effect the fired colour. Proprietary media can be obtained (for example, screen printing medium) which dry off at a much faster rate than the oils which were used in the past, such as spike oil of lavender. When mixed, the 'paint' can be applied to the work by brush.

Overglaze colours can also be obtained in tablet form and are mixed with water as a painting medium. They produce pale colours and are more suitable for large areas of work. It is possible to cause the colours to more easily fuse to the base on which they are painted by the addition of a very fine flux known as 'printing flux'. This effectively means that less heat is required to fire the work. Printing flux also enhances the gloss finish of enamel (overglazes without printers flux will appear to be matt when fired).

The kiln

The kiln which is used by the enameller will be chosen in accordance with the type of work which is to be undertaken; however, even for small work, the temperature should be able to reach 900deg. C. If larger work is to be tackled, such as vases or plates and pictures, 1300deg. C would be a more suitable working temperature - the smaller kiln being used mainly for miniature or jewellery work. It should be remembered when contemplating the acquisition of a kiln (or muffle furnace), that it can also be used for the heat treatment of metal in connection with other areas of amateur metalwork and careful thought is well advised before purchasing this equipment. It is also extremely useful to obtain a kiln that is fitted with a pyrometer, (usually a thermocouple), which allows the temperature to be accurately monitored. This is essential for gold and silver work.

Kilns which are fitted with a thermostat are much more easily controlled. Some enamelling kilns are supplied with an inspection window in the door, and this is a very useful facility. It averts having to open the door to view the progress, which allows the heat to escape. Kilns can be fired by gas (bottled or domestic) or electricity and the choice is left with the individual. Simple firing hearths can be used for enamelling small, simple pieces of work, without the need for a kiln. A small set-up is built which allows a blow torch to be played upon the under side of the work and distribute the heat uniformly. A hood should also be provided to help to retain the heat. A little practice is required when using this method, but some success can be enjoyed by its use.

Firing and safety equipment

In addition to the kiln, a few other items of equipment will assist in the execution of the work. I include within the classification of essential equipment, safety equipment, and here is a good point to stress that you cannot take too much care when dealing with the high temperature heating of anything. Even careless boiling of water can have disastrous results as we know, so heating metals and other substances to temperatures of over 1000deg. C should be undertaken with an awareness of the dangers.

As well as the heating equipment being sensibly sited where it cannot accidentally ignite any nearby materials, liquids or gasses, the work when removed from the kiln should also be placed in an area (which

is intended for this purpose) called a cooling slab (made from heavy gauge steel for example), and a small ledge near the mouth of the kiln is a real advantage. Safety glasses should always be worn when using heating equipment - if the substance spits, the eyes are so very vulnerable. Also clothing is best protected and a leather apron is a good investment, the sort which welders wear being a suitable type. Heat proof gloves too are an advantage. These items are the kind of protective wear which anyone involved in heat treatment should already possess.

First aid

Should a burn be experienced, it should be dealt with immediately. A burn can be inflicted in seconds when dealing with the high temperatures associated with enamelling. It is therefore essential to know how to deal with it. A presence of mind must always be maintained, as the equipment must be made safe and a gas torch should be extinguished and stowed in a safe place. The gas cylinder should also be shut off at the regulator.

Clean cold water can be applied to a burn in any quantity, but the area around the burn must be kept especially clean to prevent infection. The injury should be covered over with a dry burn dressing and never with cotton wool or materials which will allow particles to stick to the burn. It is wise, also, to avoid the sticky variety of ointments which are generally found around the home. If the burn is considered serious it should be treated by the casualty department of the nearest hospital. Burns can cause shock and the driving of motor vehicles should not be undertaken. Get someone to drive you to Casualty. Within the first aid cupboard, which should always be well stocked, should be a supply of Acriflavine based burn dressings.

Fire hazards

There is also the danger of fire in the workshop and familiarity with the different types of fire extinguisher is essential. Probably the best type of fire extinguisher is the dry powder variety. Supplies of water and/or a fire blanket may be kept to hand and a bucket of sand is also a good precaution. However, water should never be used to attack a liquid petroleum gas (LPG) fire. The dry powder extinguisher should be used here and the instructions for use should be familiar to anyone using the workshop, in case it is needed.

Work handling

When the work is placed inside the kiln it must not touch the walls, floor or roof of it, in order to permit the heat to circulate freely around the job. This means the use of supports to hold the work inside the kiln and these supports are used frequently. They must, therefore, be able to withstand repeated firing - many times. Mild steel is a good material to use for this purpose. Stilts and tripods can be made to suit individual requirements.

A safe means of loading and unloading

QUICK TIP

Inching towards metrication

The National Association of Steel Stockholders has introduced a range of true metric standard dimensions for sheet and plate. Therefore, from 1 January, Imperial sheet and plate sizes are no longer being considered as standard.

work to and from the kiln has to be considered and such items as tongs or a two pronged fork are indispensable.

Application Equipment

Wet enamel paste can be applied with a number of different utensils including spatulas, brushes and sharpened sticks. Pointed objects are very useful for this purpose and dental probes are widely favoured. Dry enamel powder can be sprinkled over the surface of the work uniformly and a fine mesh sieve can be used to prevent large lumps from being deposited.

The 'overglazes' which, as we have already seen, are mixed up with a painting medium, can be applied using a range of paint brushes and thicker, stiffer bristled brushes can be used for stippling. For cross hatching, a very sharp, pointed tool is used and one can be made using a needle fixed to a handle or holder.

Cleaning the metal prior to enamelling can be done with abrasives such as carborundum sticks or pumice powder, fine steel wool and stiff bristle brushes. However, the best way of cleaning is by the careful use of acids (sulphuric and nitric) but these should always be used with extreme caution and not at all by anyone who does not feel that he is competent to do so. Hydrofluoric acid should never be used at home. Apart from the injury it can cause, it will dissolve enamel (and glass)-powerful stuff! For the less experienced, forget acids and use the specially prepared pickling solutions, adhering strictly to the directions supplied with them. A good safe pickle can be made up by using vinegar to which salt is added.

Getting Down To Work

It is assumed that the metal object which is to be enamelled has already been made, or in any case that it is an item which already exists. The metalwork will have to be prepared for the enamelling and all the sharp edges or burrs should be removed with a file, because surface tension can build up due to the these burrs and can cause hairline cracks in the enamel during firing. Annealing will also reduce stresses that have built up in the work due to bending, spinning, hammering etc., and this can be carried out using the kiln. As a general rule, ferrous metals are heated until they become red hot and the kiln is switched off, allowing the metal to cool down slowly. Non-ferrous metals are usually the opposite, being quenched in water immediately they are removed from the kiln. Gold however, is an exception and is cooled down slowly in a similar manner to the ferrous metals.

The metal will have to be cleaned next and this is important in order to induce the enamel to adhere to the surface. Any grease present on the surface can produce disappointing results, so beware of leaving finger marks on polished metal.

Metal can be cleaned and polished by using various abrasives, but the easiest way of cleaning the base for enamelling is by pickling.

Applying the colours

After pickling, the enamel can be applied to the work. It should not be put on too thickly and a few thin coats built up and fired separately are preferable, as they are likely to adhere better. When enamel is applied in the form of paste (especially for inlaid work), a thin gum is mixed into the compound to help it to adhere and if the enamel is applied in the form of powder, the work can be painted with gum with the same advantage. This gum must have the ability to dry out and not leave residues which may adversely affect the firing.

When using paste it is important to use the correct consistency and experience will help make this possible. The substance is best used in a dish which is tilted, to allow the water to run to the bottom, so that it will not be too wet to apply, but water can be added if it is too thick for intricate designs. The various application tools are used to apply the paste and when this is done, the object is tapped gently with a piece of wood, which brings any air or excess moisture to the surface, and helps

even out the paste. The excess moisture can be dried off using blotting paper.

Designs can be painted onto the work using the thin gum and fine enamel powder sprinkled over it from a distance of around 100mm. The powder then sticks to the gum, which prevents it from being displaced before it is fired. When working on dishes or high sided articles, a thicker gum may be necessary which will not 'run' on the vertical surfaces. Heavy lines and shadings can be executed by applying the powder by means of a folded paper 'V', which is laden with fine enamel and lightly tapped, allowing the powder to spill over the work and form a 'trail'.

Another enamelling technique is the covering of the reverse side (or counter side) of the work. This method is called 'counter enamelling' and is carried out for several reasons. Any of the high firing enamels can be used and more than one firing may be called for. If very thin metal is used as a base, counter enamelling stabilises the stress set up by the enamel layer (or layers) which is applied to the primary side, especially when this coating is particularly thick. It also prevents the work from distorting out of shape. In many cases, counter enamelling prevents the cracking of the main glaze. If firing is to be carried out with an open hearth and a blowtorch instead of a kiln, counter enamelling may be found to be very difficult. To get the fine 'painted' enamels, the metallic oxides are used to obtain the colours mentioned earlier. As the name suggests, they are simply painted on, although they are sometimes applied with a point. Each colour is separately fired.

Firing work

The object of firing the work is to cause the enamel to melt or 'fuse' and adhere to the base metal very soundly. As we now know, several firings are required for all but the most elementary designs. Apart from the temperature, the most important single factor is the length of time taken to fire the work, and this period is influenced by the many different conditions which are to be found. The size of the job is obviously important, as is the thickness (or gauge) of the metal. The type of metal too has a large bearing on the firing time. The amount of enamel which has been applied has to be considered, as has the stage which the work has reached (firings may already have taken place). In any event, for the type of work which is undertaken by the home

Table 2a
Approximate Firing Temperatures

Inside of kiln appears	Application	Temperature (deg.)
Cherry Red	Soft-fusing enamels	750 - 790C 1382 - 1450F
Bright Cherry Red	Medium-fusing enamels	790 - 820C 1450 - 1508F
Bright red	Hard-fusing enamels	820 - 850C 1508 - 1562F
Orange/red	Large and thicker gauge work	950C 1742F

enthusiast, the firing time will, in many cases, be less than one minute (for small work) and even on larger work, should rarely exceed two minutes. It will be clear, therefore, that the work is placed in the kiln when the firing temperature has been reached inside, and is not allowed to warm up with the kiln. As the job does not touch the walls of the kiln, care must be taken with the positioning of supports, so that there is no danger of damaging the melted enamel, or worse still, the support adhering to the work.

When the work is placed inside the kiln, it must be absolutely dry. Any moisture still present in the enamel will very quickly boil at these temperatures and can cause serious problems with dislodging enamel. Jobs can be placed on top of the kiln whilst waiting for it to come up to temperature and this will assist in drying out the moisture.

When it is certain that the moisture has evaporated, the object is placed inside the kiln, already mounted on its support and tongs or another suitable utensil are used to do this carefully. The two pronged fork is extremely useful here. No undue knocking or jolting is permitted as the enamel is now quite dry and delicate, and is easily damaged by shock.

Firing then, is to raise the temperature of the metal to close to the melting point, as the enamel simultaneously melts and fuses to the red hot metal, forming a smooth layer upon it. Just before the enamel 'flows', it becomes a surface of small craters and the firing is halted at this stage by some enamellers who wish to retain this finish as a decorative effect, which they call 'orange peel' finish. A short firing at the correct temperature is far better than a longer firing at a lower temperature. This rule will produce sharper, more vivid colours.

If the temperature is too high or the work is left in the kiln too long, 'overfiring' may result. When this happens, the enamel can quite possibly be burnt out altogether and the edges are blackened. Some colours may be lost altogether and on repeated firings, the colour can sink into the enamel below it. In extreme cases of overfiring, the base metal itself may be burnt or melted. Care must be taken therefore, to prevent overfiring and regular checks throughout firing should be made - either via the window in the door (if fitted) or by actually opening the door and looking into the kiln (with a consequent loss of heat). Underfiring, although not as serious, can also occur. As its name indicates, insufficient heat or too short a firing time are the causes of this predicament. It can be very easily rectified by re-firing under amended conditions. Underfired work can be identified by an appreciable lack of lustre in the colours or a lack of transparency in the translucent colours (which will appear opaque). Some craftsmen deliberately underfire work which has to be multi-fired, saving the correct firing for the final stage in the kiln.

When fired, the work is removed from the kiln and allowed to cool slowly.

Finishing off

When the work has thoroughly cooled it, can be inspected for cracks or flaws and any surplus enamel can be removed with a carborundum stone. Similarly any bubbles

or irregularities can be stoned away, but it should be remembered that stoning leaves a matt finish. The gloss can be restored, however, by polishing. Stoning should always be carried out with the workpiece submerged in water, so that the dust which is removed is not ground back into the enamel surface. Better still is to do this work under a running tap.

To polish enamel, a polishing mop may be used, but unlike during metal polishing, the mop rotates much more slowly. For one reason the operator has more control of the job and for another, much of the polishing is done wet and a slow mop does not throw water about in the same way. Even though the mop is running at a slow speed, normal safety precautions should be observed, including the wearing of eye protection and the offering of work to the mop below centre height.

(It may be found to be useful to read the article on metal polishing by the same author, *MEW* No. 16, before attempting any

polishing work for the first time.)

Pumice powder is used as an abrasive for polishing and this, even in fine grade, will be the coarsest of the abrasives which are encountered on this type of work. Rottenstone and putty powder can be used for the finer finishes. Jewellers rouge will give a high gloss finish to work, but should only be used on a fluxed surface, as it can cause stains on certain types of enamel.

We have now covered enough ground to produce elementary designs in examples of enamelled metalwork. This is by no means the whole story of enamelling but good work can be produced at home and may act as an introduction to the art. After a gaining some experience of creating small, simple objects, the craftsman will be ready to tackle more advanced work. Here, 'craftsman' is used as a general term as much of the best enamelling work is produced by women. A future article will deal with some of these more advanced techniques.



Table 1
Suggested Colours For Stock

Flux	The vitreous uncoloured base of enamel. High firing flux is required for silver or silver foil. For overglazing, a 'soft' or 'super soft' flux is required.
White	A hard white is used for most work and a specialist 'dial white' is available for watch/clock faces.
Black	Only a small amount of black is normally needed.
Amber & brown	Ambers range from mid-brown to light gold. Darker shades are classed as brown.
Blue	Many blues are available. Transparent blues tend to improve by repeated firing.
Green	A wide variety of greens is also available, emerald green being one of the most popular. Certain opaque greens can be difficult to fire in thin smooth layers. Leaves are a favourite design for the greens.
Grey	Small amounts of grey can be useful.
Orange & yellow	Opagues should be fired on a white or flux ground.
Pink	Care must be taken when firing pink and this colour is better fired on an opaque white ground.
Red	Certain reds go dull or darken at the edges after repeated firings. Translucent and opaque cherry red is one of the more popular reds.
Turquoise	The transparent turquoise colours particularly enhance a base of silver.

Table 2b
Firing temperatures for:

Steel	800 - 820C 1472 - 1508F
Transfers and a pre-fired ground	650 - 700C 1202 - 1292F
Metallic oxide overglazes	720 - 750C 1328 - 1382F
Lustres	700 - 730C 1292 - 1346F

AN ELECTRONICS ENGINEER **WHO FAVOURS** **MECHANICAL DRIVES**



1: A general view of Jim Canner's compact workshop.

2: The Centec 2A Milling Machine.

3: The Kennedy Hacksaw Machine under restoration.

4: Jim with the motor for the Kennedy hacksaw.



Jim Canner is at home in two worlds, professionally he is involved with electronics, but his activities in his home workshop tend to favour things that go round....

Jim Canner declares himself to be a man fascinated by things that 'go round' and his workshop illustrates this clearly. A brass beam engine, a vertical stationary engine, a couple of small locomotives, the makings of a hot air engine..... The list could go on.

Jim was trained as an electronics engineer, but his apprenticeship contained a large mechanical engineering element, so he feels comfortable in both branches of the business. His current obsession is with power transmission systems and he will readily demonstrate a couple of miniature continuously variable speed drives which are based on the principle of the adjustable stroke crank. The first to be made proved to be slightly 'notchy', so the improved version was developed and certainly feels very smooth in operation.

On the bench, a Kennedy hacksaw machine is in process of restoration and extensive modification. One of the modifications will be the incorporation of a two speed drive, the design for which he promises to share with us in a future issue. It will be suitable for application to any electric motor that can be reversed and could well be an answer to those who



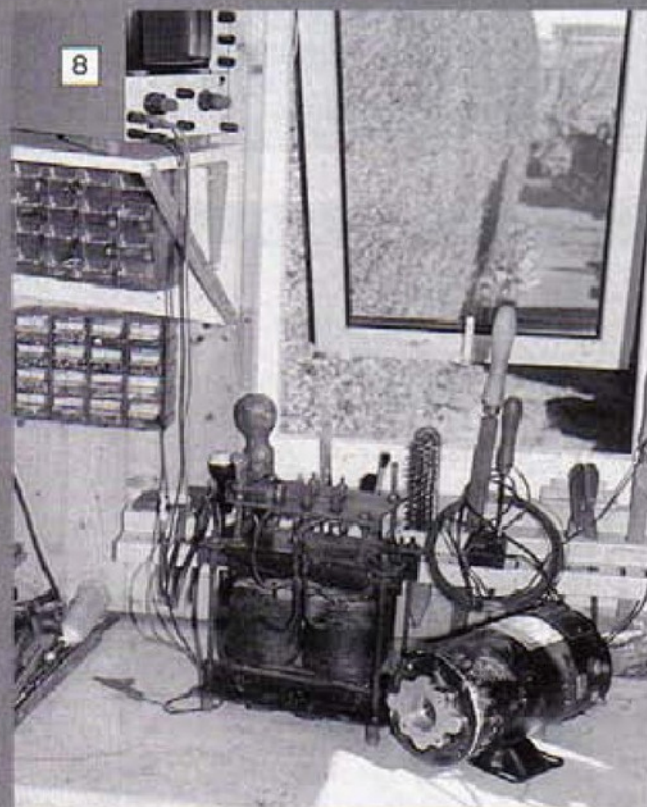


5: Jim assembles the two-speed drive for the Kennedy.

6: The mechanical two-speed drive assembly.

7: Another on-going project, The CARD lathe.

8: An antique transformer for a battery charger and a DC motor on the electrical bench.



are grappling with the problem of getting the spindle speed of a machine tool down to manageable levels.

As he states in his article on draw bars elsewhere in this issue, his equipment consists of a Myford Super 7, a Centec 2A milling machine and a number of small drilling machines. At the end of the workshop is the 'electrical department', complete with oscilloscope. Residing on the bench is an antique-looking transformer which is destined to form the heart of a charger for the batteries which will power the large DC motor which is also in evidence and which Jim intends will power a small car. Again, the variable transmission system will be mechanical because, despite his background, he feels that people do not really like the thought of electronic control systems.

A discussion with Jim in the atmosphere of his workshop is a stimulating experience as his fertile mind is continuously ranging over ideas for new projects and new angles on old ones, which are all committed to paper in a succession of notebooks, for as he says, if you don't write them down, some good idea will be forgotten.

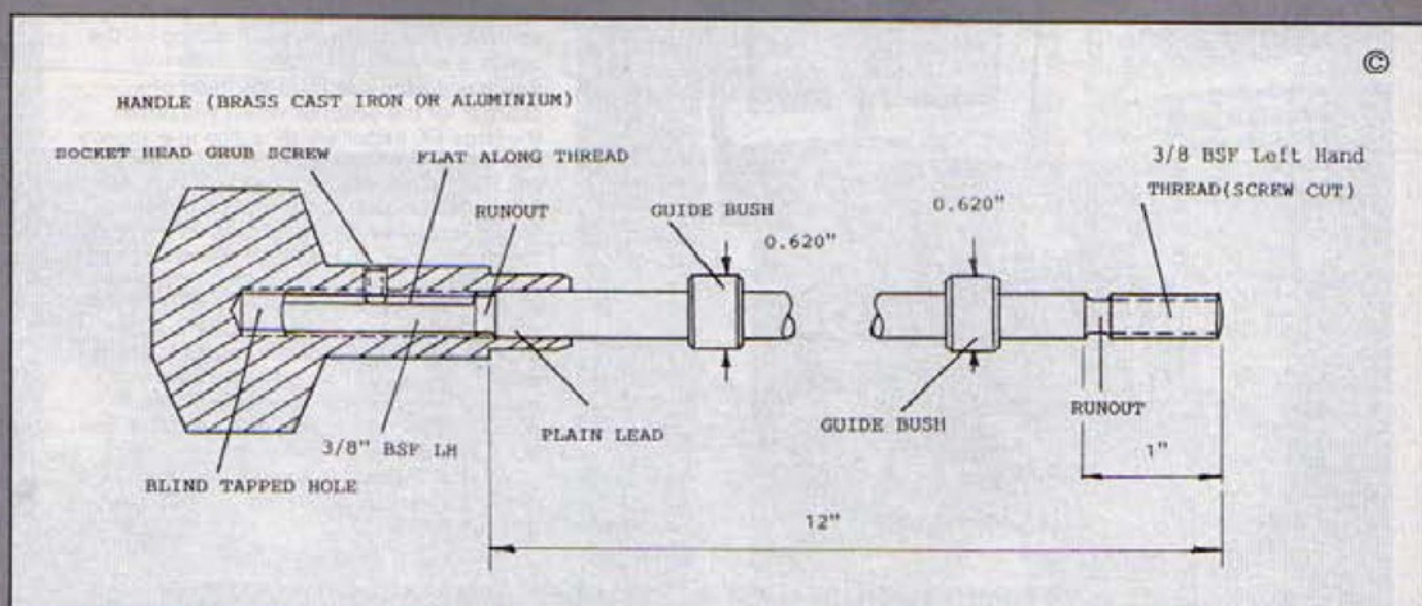
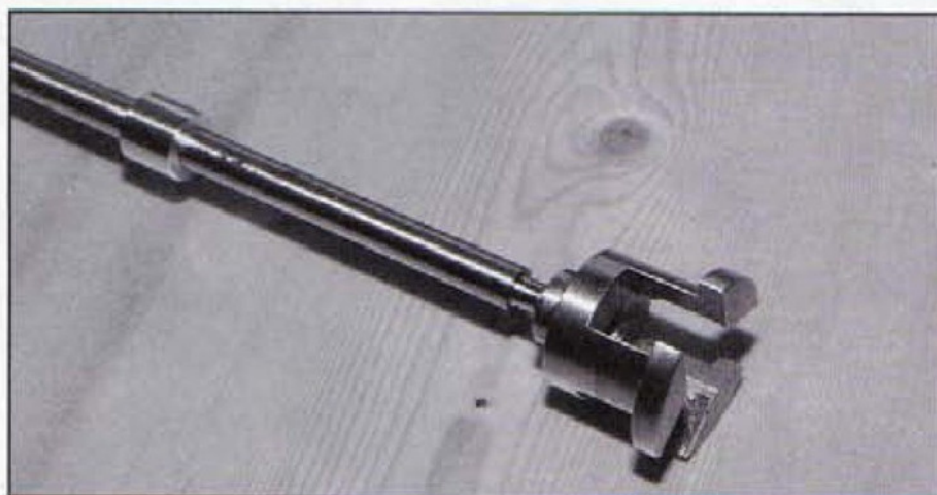
We look forward to seeing more of those ideas translated into designs for M.E.V.



NO HOLDS BARRED

Having introduced the subject of lathe draw bars in our last issue, Jim Canner develops the theme with a device which will remove some of the risk from a machining operation.

My previous dissertation was on draw bars and I continue with the same theme here but with a slightly different emphasis. It has always surprised me that the Myford Super 7 lathe is provided with a reversible induction motor and that an approved switch can be fitted, allowing for almost instant reversal. There must be a reason for this but there is no information in any literature that I have seen that tells the user how to avoid the chuck unscrewing should a jamb occur when reverse is selected. This kind of thing worries me and I have always wired my switch for forward running only; this is O.K. for me because I am a qualified Electrical Engineer and am able to take all the necessary safety precautions, but for others it may not be quite so simple. I remember buying a DIY bench grinder,



made by a reputable company, that used a belt driven wheel spindle and a universal motor. All seemed to be O.K. as the nuts on the spindle were of the correct hand for the direction of rotation but what had been forgotten by the designer was that on switch-off, the wheels tried to go faster than the machine spindle. All a matter of inertia! Suffice it to say, the machine moved on with a warning to the new owner.

To move on, some modern lathes now have bolt on chucks, so at least some manufacturers have appreciated the problem and dealt with it. But my lathe is a Super 7, for which I retain the epithet Super, and I decided to do something about what I consider a failing. "Why", you may ask, "do we need to run our lathes in reverse"? That is a good question, because in fifty years I have never needed to do it. I have always got around the problem. However, I can think of three good reasons:

1. Screwcutting outwards from a blind hole with the tool inverted (reduces adrenaline production).
2. Die screwing studs on power, in and out.
3. Using some of my 160 left hand high speed drills which were given to me many years ago!

Another reason may be that if we were not interested in machine tools and improving them, we should probably not be reading *Model Engineers' Workshop*. Also it gives me another opportunity to subject you to more draw bar facts. So, we need to make a draw bar that will hold on to the chuck when the spindle is reversed. This suggests a draw bar with a left hand thread at the chuck end screwing into a thing that grabs hold of the chuck without impairing use of the chuck. Well, we can't have everything and I'm afraid work holding will be slightly impaired because the draw bar has to go through the spindle and therefore the work can't. Length is therefore the limiting factor, but the whole clamping length of the jaws is available.

The Spider

I made much swarf doing this job, but eventually came up with a spider device with slots, so that the three jaw chuck jaws would clear it. At first sight, when designing for a particular chuck, it seems that there might not be enough metal left in the spider to do the holding job. This is why I made so much swarf, but in the end everything came out nicely proportioned. The spider fits in the chuck recess and grips against the front face of the chuck, with the jaws passing through slots. The device is totally chuck dependent, so I can give you only a general drawing and point out where you need to put in your own dimensions. Please make a little drawing first, as it could save you lots of time later on. On my own chuck the recess is 1.156in. dia. and the jaws are 0.56in. wide.

NOW FOR A RADICAL SUGGESTION.

It is not necessary that your chuck recess be concentric to the lathe spindle, but consider boring it out so that it is! If you have a chuck with a cast iron body this

QUICK TIP

Alternative storage

As it is now nearly impossible to get hold of tobacco tins for those odds and ends, try using 250g. margarine boxes. They are a little larger, but are stackable and quite durable using a little care. You can write on them with a felt tip pen

Derek Walters

should be a piece of cake, a steel body may be more difficult. I suggest this because I have other plans for your three jaw, and a concentric recess would be handy, but not essential. Making the spider is fairly easy but should be approached in a logical manner to achieve a professional result. When I first started this job I remembered that seven years ago, due to a lack of workshop after a move, I had thrown some odd ends of steel under a hedge in the garden. I looked and found these ends in a very sorry state, well rusted and pitted all over, but I guessed that the rolling mill stressed surface would be gone. Having used it all, I have not experienced any springing after machining, so look out for rusty steel, but put a paper towel over your lathe bed when turning the rust off! You may not have the luxury of well rusted material to do this job, so I suggest that you select some that is well oversize, chuck it in the four jaw and rough it down all over to about 20 thou over the maximum diameter shown in **Figure 1**. This should go some way to eliminating the springy skin. With this blank held firmly in the four jaw, face and centre. Now turn the $\frac{5}{8}$ in.

QUICK TIP

End Mills and lathe chucks

When using screwed shank end mills and slot drills in a lathe chuck, fit a suitable nut, which can be hooked behind the jaws. This will prevent the cutter from working out of the chuck whilst cutting.

K.H. Sprayson

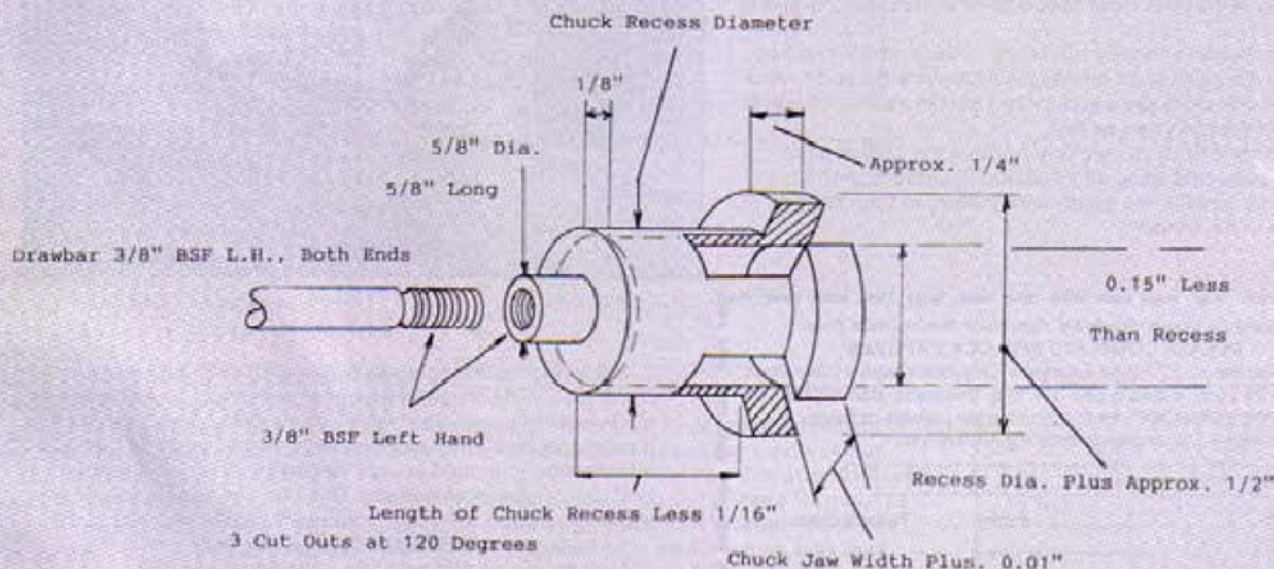


Fig.1 Spider - Mild Steel

A 5 $\frac{7}{8}$ in. Dia. GEARED ROTARY TABLE



A rotary table can be a useful adjunct to the milling machine and can also be used on the lathe. Mark Figes gives us detailed instructions on the manufacture of this all-fabricated version, the design of which is based on the use of commercially available gearing. For those who have constructed Geo. H. Thomas' s Versatile Dividing Head, a modification is shown which will allow the fitting of its division plates and micro attachment, thus extending the capabilities of the table.

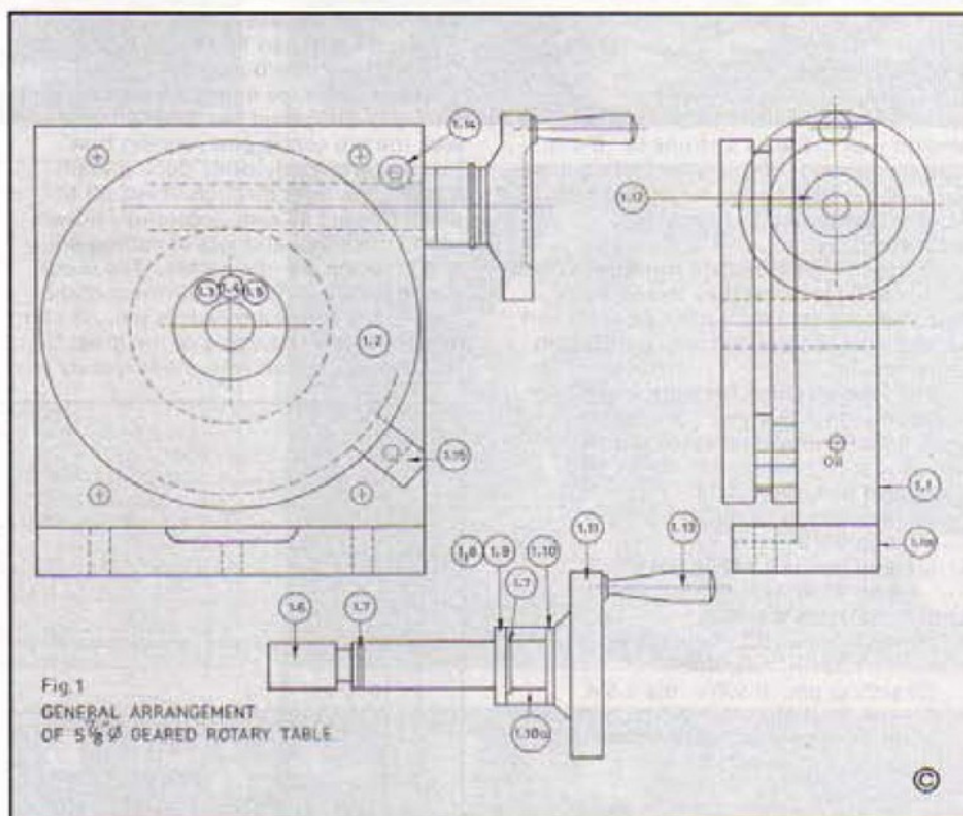
This rotary table was designed to be compatible with other pieces of equipment in use in my workshop and to combine features that I have not seen in other rotary tables. It is of all steel construction and can be used in both horizontal and vertical positions. The height is 2 $\frac{3}{8}$ in.; on small milling machines where 'daylight' is restricted, a low overall height was considered to be essential. The fixing holes will cover 'T' slot centres from approximately 3 $\frac{1}{2}$ in. to 5in. The table was built using a 'Myford' 3 $\frac{1}{2}$ in. lathe, a 'Senior' M1 milling machine and a $\frac{1}{2}$ in. pillar drill.

The use of a 60:1 ratio makes it fully compatible with the division plates of G.H.Thomas's Versatile Dividing Head and his Headstock Dividing Attachment. I designed it incorporating a nominal 3 $\frac{1}{4}$ in. bore, allowing use of G.H.T.'s split collet system as used on the V.D.H. and on his Universal Pillar Tool accessories. The same bore was also used by 'Tubal Cain' on his Master And Slave Chuck. (M.E. Vol. 167 No.3909) These spigots are located, centred and locked by 3 radial push rods that do not interfere with either the table surface or 'T' slots. The centre bush is tapped 5 $\frac{1}{16}$ in. BSF, to enable a direct fixing to be made through the centre of components.

The handwheel has a friction thimble graduated in 60 divisions, thus giving $\frac{1}{10}$ deg. — no confusing minutes and seconds; the table is graduated 0-360deg

The worm is mounted in 'Oilite' bushes with needle roller thrust bearings, to give a really smooth action with zero backlash; the curse of any milling operation. The worm can be easily withdrawn for centring and setting up. The table is locked by a 'pull down' type of clamp, being secure without distortion.

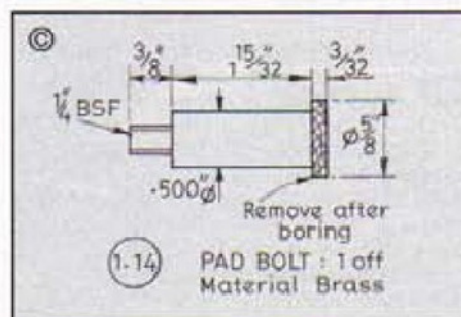
Items such as gears and worms are readily available from 'the trade', an almost universal approach in industry,

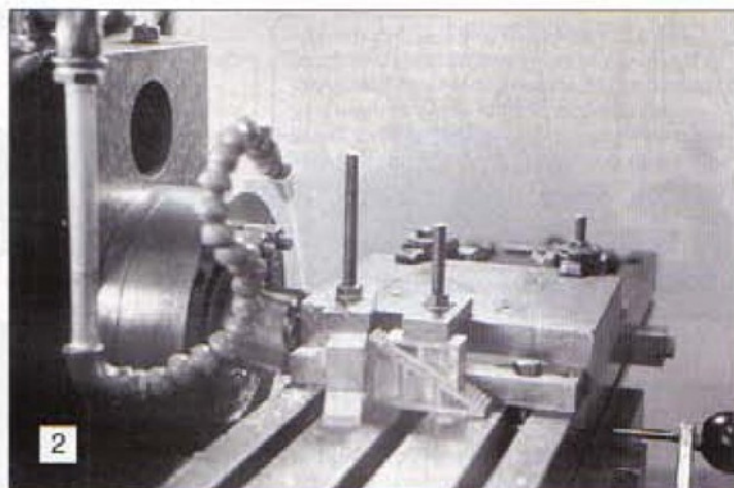
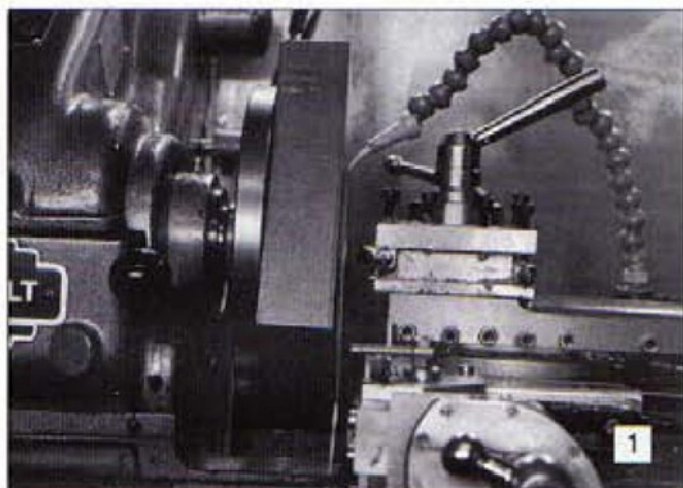


especially as the main gear is helical cut.

The method described below is the way 'I did it'. In writing this article I have laid it out in a stage by stage format, as experience showed it was all too easy to dig myself in to a hole which was very difficult to get out of if I got any operations out of sequence. Don't we all?

Some years ago when enquiring of a trade supplier if I needed any special tooling to make the product I was interested in, he replied "yes, an A, a B and a dustbin". "What for? I'm not





planning to scrap it" I replied. "No sir, just for the swarf," came the response! The man was right, only this job is bigger! Some of the machining operations described may be considered unconventional, but I used them and they are considered normal in industry.

Because of the size of the base, it will not swing in the 4 jaw, so I have used 'tooling holes' to fix to a faceplate, which when finished with will become oil reservoirs.

Enough waffle, time to get dirty and move some metal.

Preliminaries

1. Important Item 1.3 in the original design was made as a shrink fit. If you find the thought of this intimidating it is quite acceptable to use 'High Strength Loctite' or PermaBond F246, (see Assembly).

2. Does your faceplate run true? Check it. In my experience they 'creep' with age, misuse etc. If it's out, set it up and skim it. If it is running true, parallelism must result.

TIP: Always check for truth when remounting on this job.

3. I had to make up some bits first which are:-

- (1) pad bolt, Item 1.14.
- (2) plug gauge, 1.5in. dia x $1\frac{1}{4}$ in. long BMS.
- (3) plug gauge, 1.497in. dia x $1\frac{1}{4}$ in. long BMS. (not needed for Loctite method.
- (4) measuring rod, $\frac{5}{8}$ in. dia x 1.324in. long BMS.
- (5) setting pin, 0.500in. dia x 3in. long Precision Ground Mild Steel (PGMS) or silver steel.

Item 1.1 Base

Select the best face of the material and find the approximate centre of the pin bore. Pop, mark off 4 holes on a 5in. PCD in the same orientation as the bolting down holes, drill $\frac{1}{4}$ in. BSF tapping right through and tap $\frac{1}{4}$ in. BSF both sides, minimum $\frac{3}{8}$ in. deep. One of these tooling holes will foul the wormbox bore, but no matter. See Figure 2.

Fit to true faceplate, (studs and nuts are easier than bolts), face off removing a minimum to get a clean face, reverse

and repeat. **Photo 1**

Square up and finish machine to dimension. I used the mill horizontal spindle (Photo 2). Note the tooling bar clocked square to the table. A large angle plate or the cross slide are other options.

Mark out (on the bottom face), true centres of:- table pin (Item 1.3), wormbox (Item 1.9), pad bolt (Item 1.14) & 4 'T' bolt holes to suit your machine 'T' slot centres. **Note:** The exact centre of the wormbox bore is obtained when setting up for boring, this is just to make sure we know which face it's on!

Drill & ream pad bolt hole, drill 4 off 'T' bolt holes, De burr.

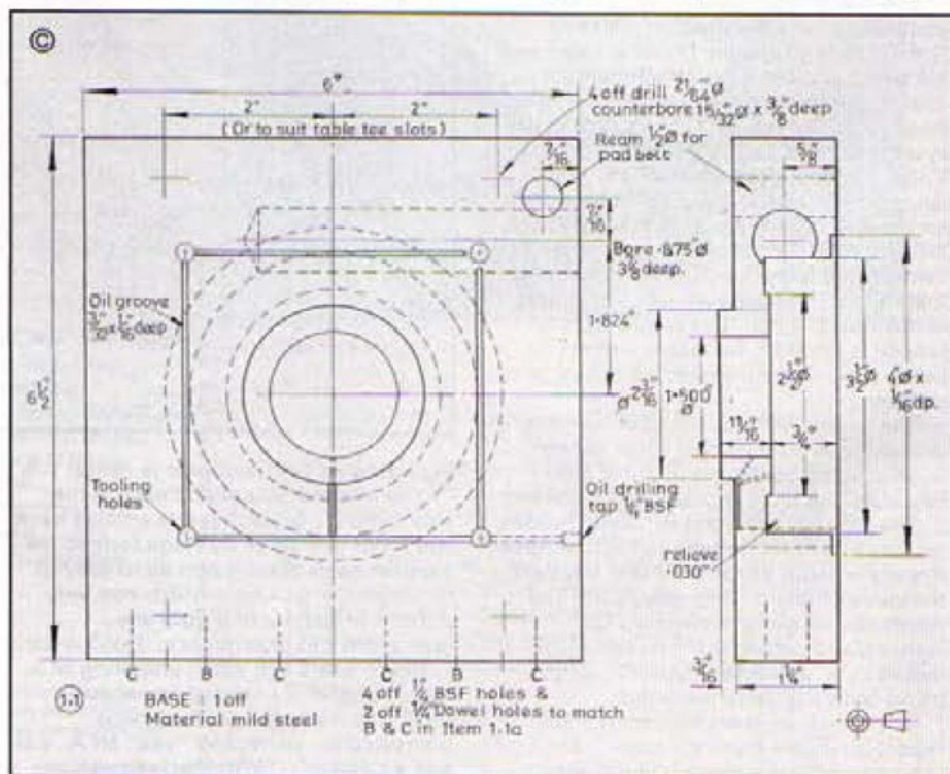
Mount the base on the faceplate, with the top side against the faceplate and with the pin centre pop running true, (using a wobbler), drill, bore & ream 0.500in. dia right through. Face off to finish (I used 55 rpm, a carefully honed round nose tool and lots of cutting oil), and bore the 4in. dia recess. The G.H.T. inside knife tool is ideal for most of the boring and reaming on this job. Yes I'm un-ashamedly a disciple of the great Geo. H. Thomas, a man who made quality tool

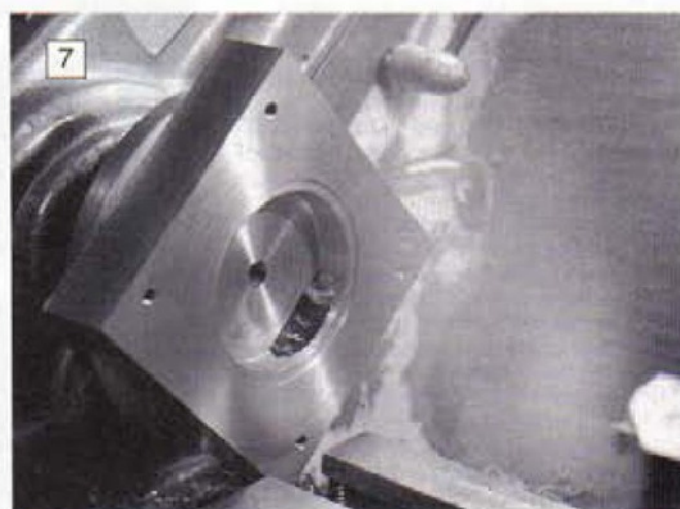
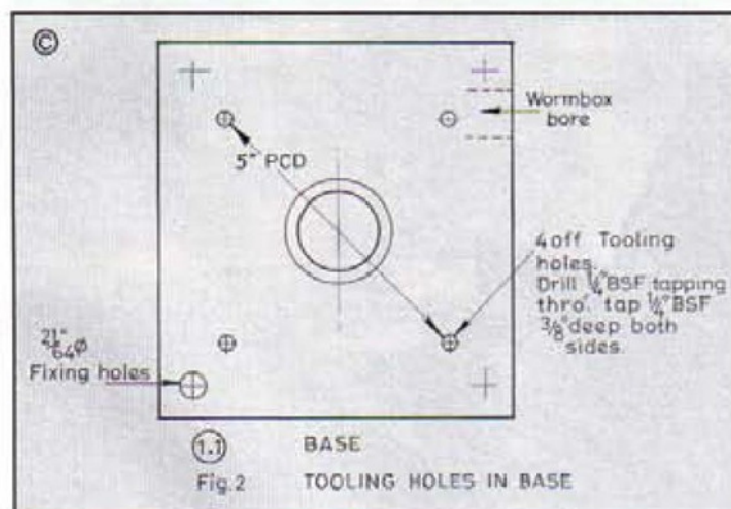
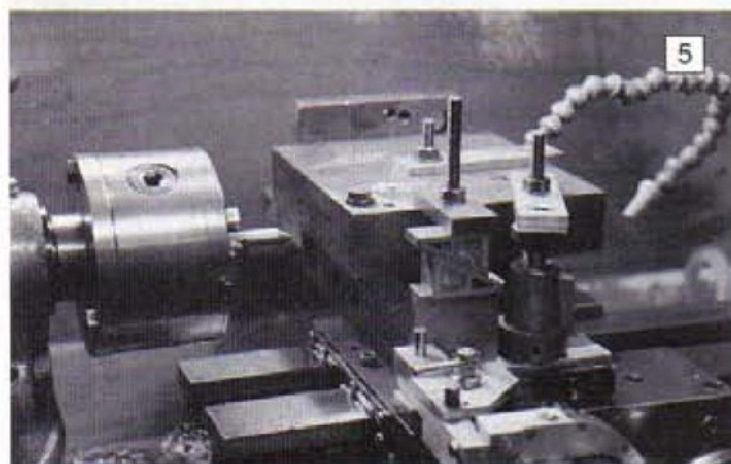
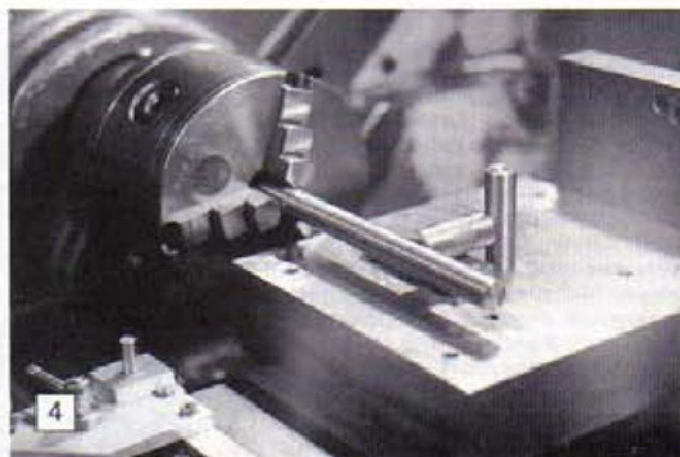
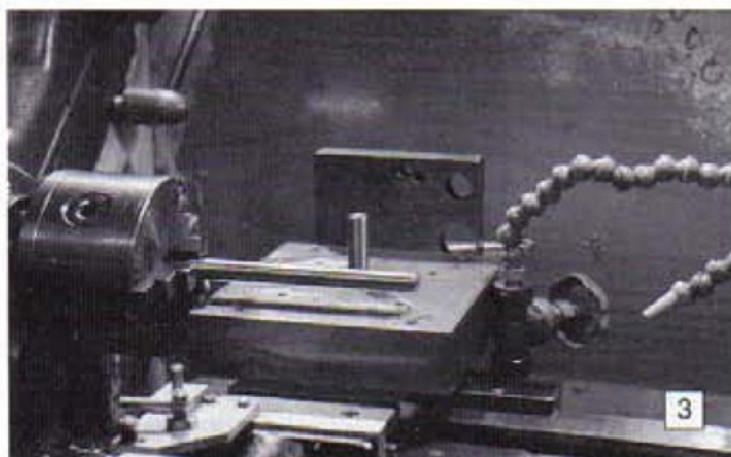
making possible for me and many model engineers.

At the rear of the cross slide fit an angle plate with at least a 3in. high leg, clocked true to the axis of the lathe. On the base, plug the tooling holes that foul the wormbox bore with bits of studding to maintain a smooth passage for the drill and boring tools: **Photo 3.**

Fit a chuck and set to run true, a 0.5in. dia PGMS bar approx. 5in. out of the chuck. Place base on the cross slide, abutting the angle plate with the worm bore facing the chuck. Fit the setting pin in the centre hole in the table and adjust the cross slide so that the 1.324in. long measuring rod just fits nicely between the two 0.5in. dia setting pins. **Lock the cross slide!!!** My long suffering lathe is rapidly transformed in to a 'jig borer': **Photo 4.**

Remove the setting pins etc. and pack the base up on parallels to bring the worm bore centre to centre height, then keeping the base firmly abutted to the angle plate, clamp down securely, clocking as you go to check. This was the most practical way I could think of to get





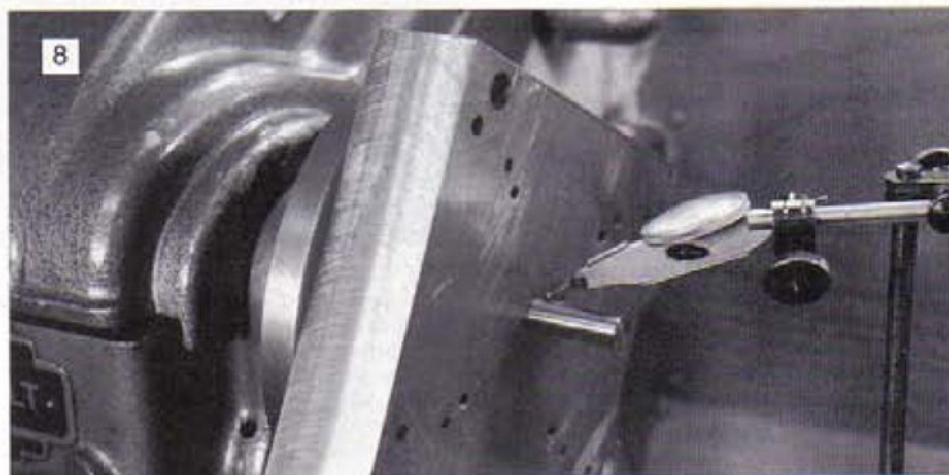
accurate gear centres: **Photo 5.**

Drill, using the tailstock as a 'pusher'; bore & ream the worm bore. If you haven't a reamer, no matter, as Item 1.9 can be turned to fit, but a plug gauge would be handy. From the photos it will be seen that lots of soluble oil coolant is being used. Don't be afraid, splash it on, it improves the cutting action no end:

Photo 6.

Fit the base on the faceplate, bottom out, using the setting pin clocked to run true. Machine the gear recess with a good finish on the thrust face (not forgetting the 0.030in. undercut). I took a final finishing cut across the base at this setting to make sure that the base was as true as possible. **Photo 7**

To machine the top, there were two options. It can all be turned off, (but this



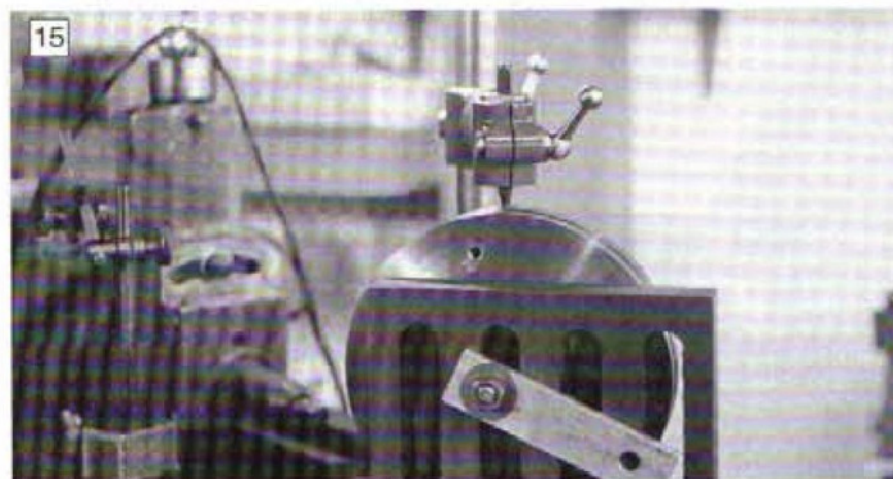
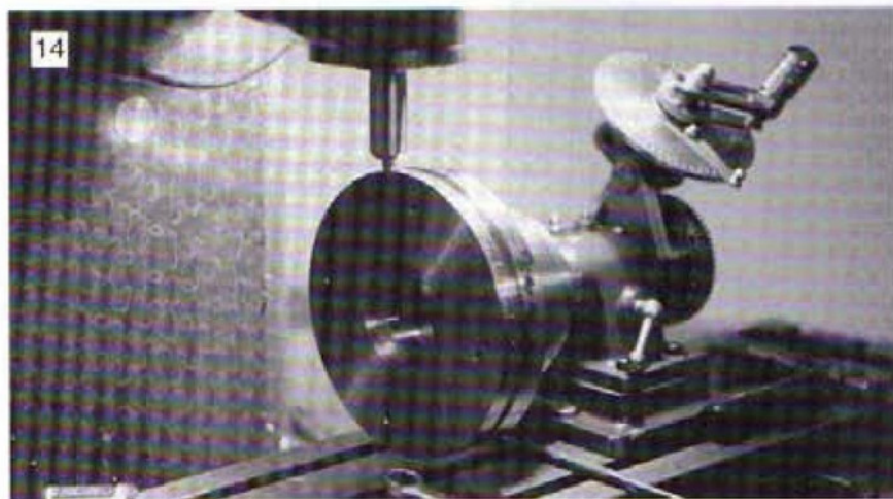


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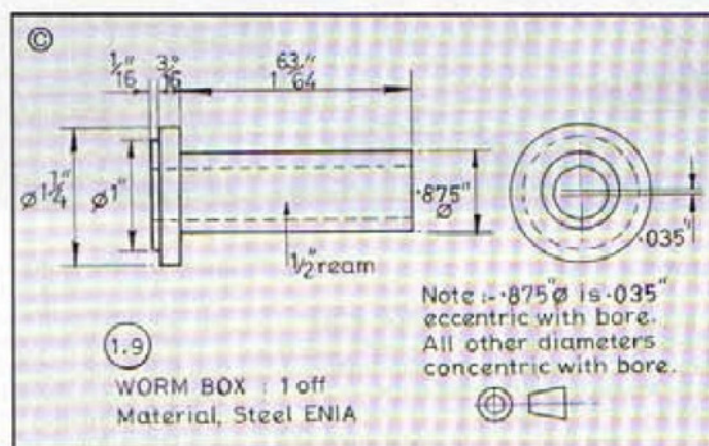
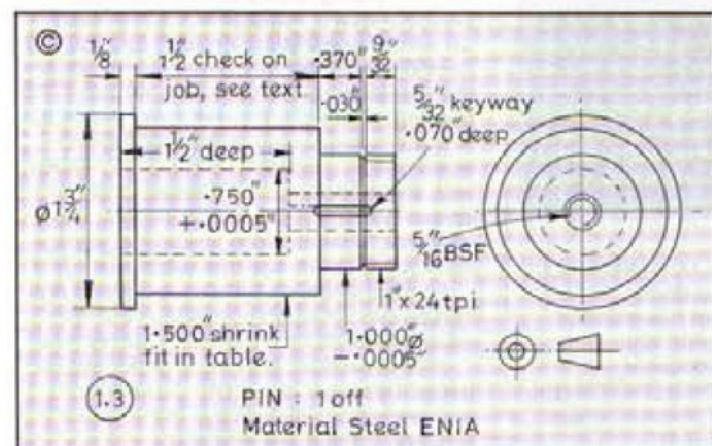
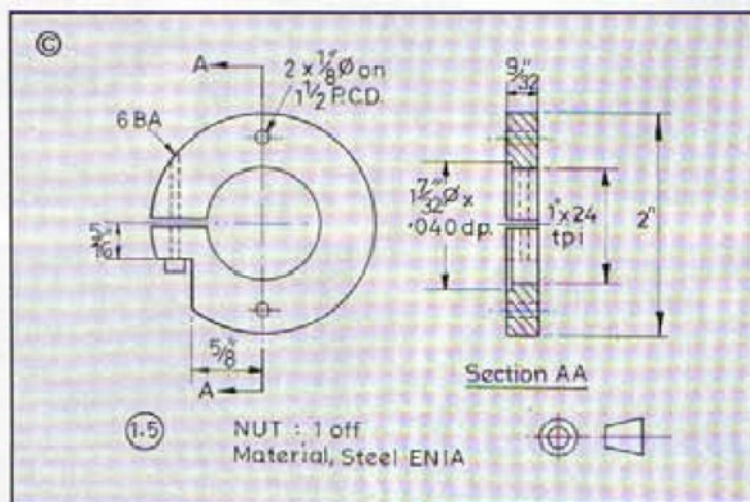
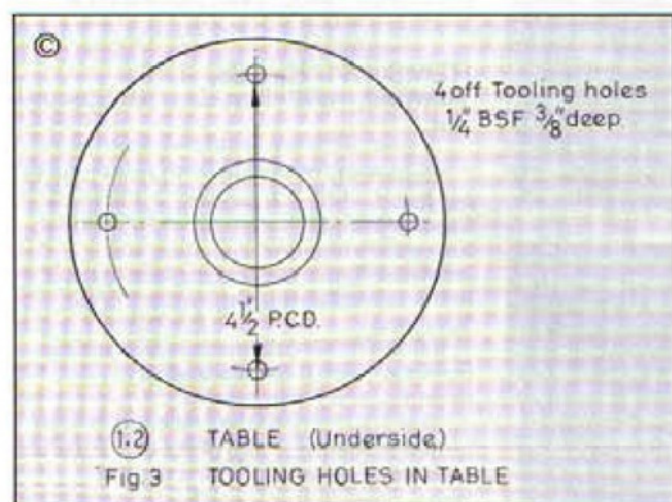
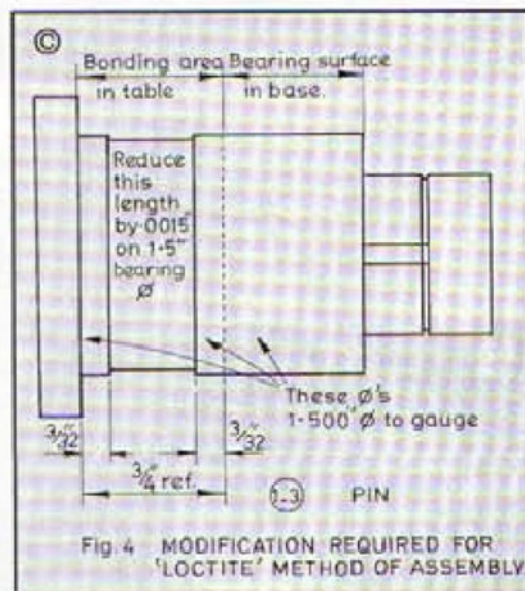
Face, drill, bore and screwcut 1in. x 24 TPI. Slit, drill & tap for a 6 BA pinch screw. This nut is used as a gauge for screwcutting the pin (Item 1.3). **Tip:** Pack the slit with a bit of stock the same thickness as the saw and nip the screw to stabilise the nut as a gauge.

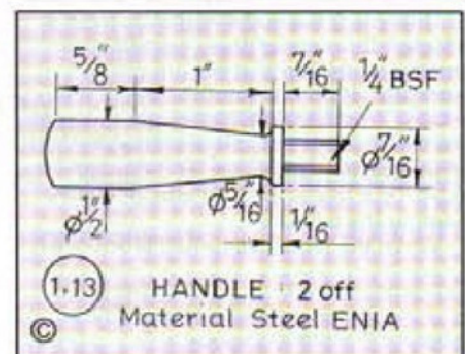
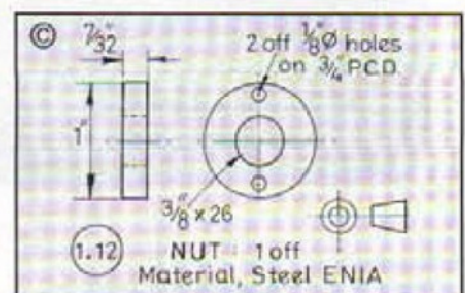
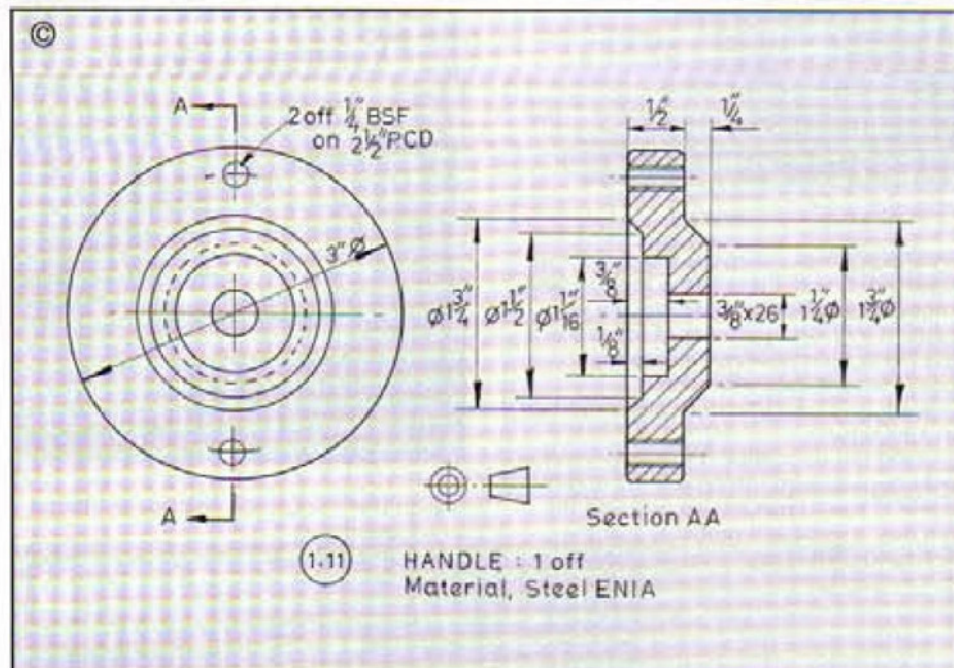
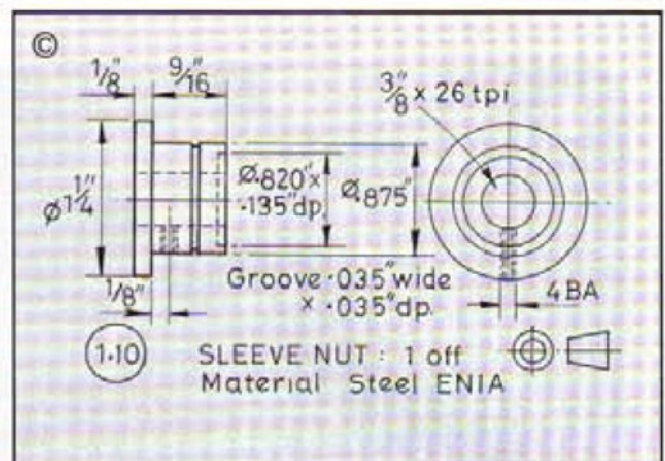
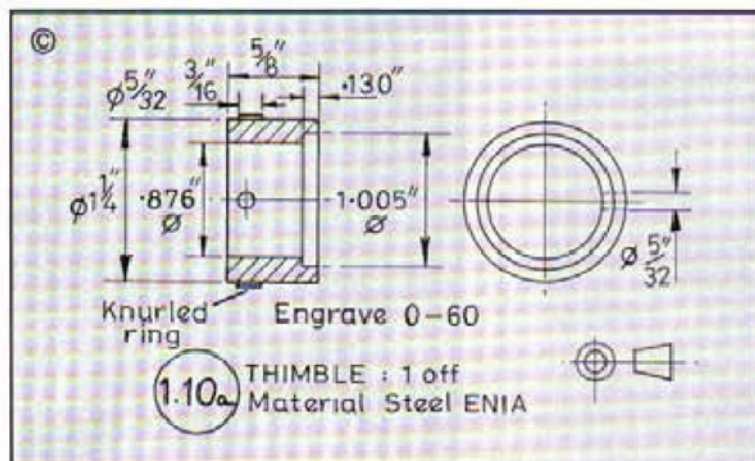




When George Thomas designed the VDH, he discussed at length, the fact that a worm meshing with a helical cut spur gear creates (theoretically) only a point contact as opposed to the line contact of a fully throated worm wheel. He came to the conclusion that, as the VDH was only to be used for positioning, not driving the workpiece, this would be of little concern.

As this rotary table was intended to be used on the milling machine, I thought hard about this feature and decided to use the same worm/wheel combination as G.H.T. for the





following reasons:-

1. Compatibility with the VDH.
2. Availability of 'off the shelf' parts
3. The proven high degree of accuracy.
4. The ease of machining and alignment and the ease of disengagement.

If I had used a fully throated worm wheel, it would have increased the height of the table unacceptably. Additionally, a full throat worm is very difficult to fit properly - if it is not dead true, you still only get a point contact. Consequently, the drawings show the specification for the worm and wheel as used in the VDH and the parts will be available with the vital bits finished machined. The masochists are advised to read G.H.T.'s book on Dividing and Graduating. For we mere mortals - read on!

Mount the ready cut and centred worm shaft between centres and turn to a good fit in the bushes, then screwcut the thread to a really 'nice fit' in the tapped parts (again making sure that the threads bear on the flanks not the crests). Carefully de burr the worm; I used a No 4

cut Swiss file with a piece of brass shim to protect the worm thread.

After that lot, there is probably a lathe under that heap of swarf. It might be time for a dig out?

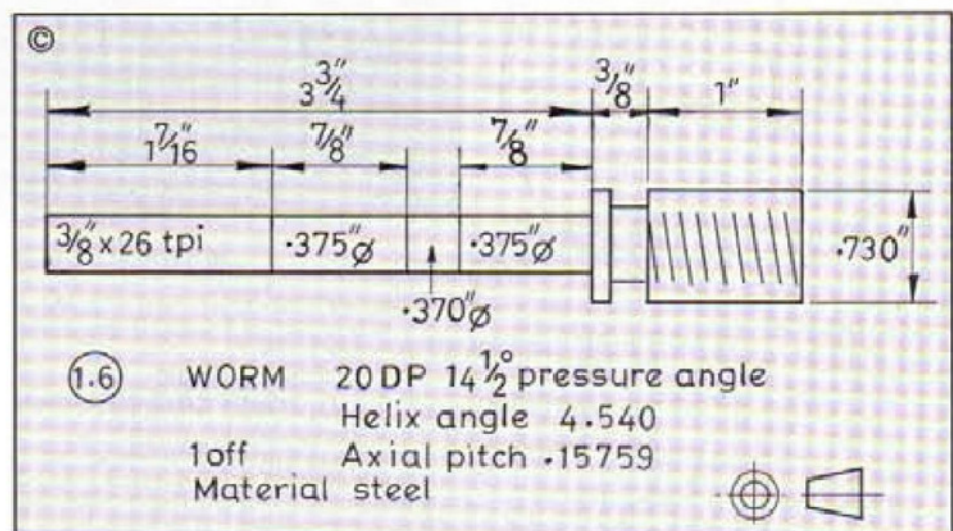
Assembly

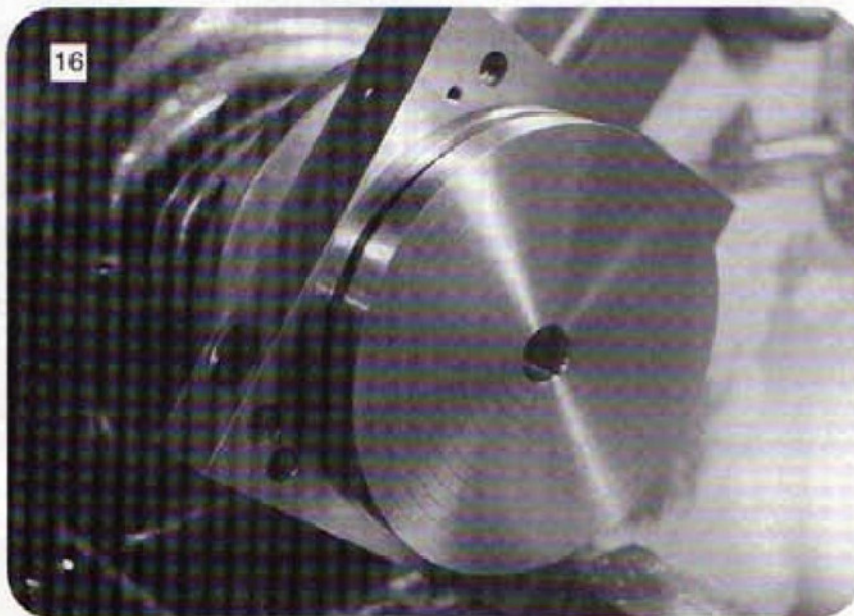
Thoroughly clean all parts, taking care with the oilways. I 'cook' the parts in

boiling water and washing soda, then I know they are clean. Protect them afterwards, you can watch them rust! Don't use this method with aluminium or its alloys, it eats them.

Table & pin - Loctite method.

Make sure all burrs & sharp corners are removed, clean with Loctite cleaner, allow to dry. Apply Loctite high strength retainer to the mating surfaces; assemble and place in a flat position for 24hrs





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undisturbed.

Table & pin - heat shrink method

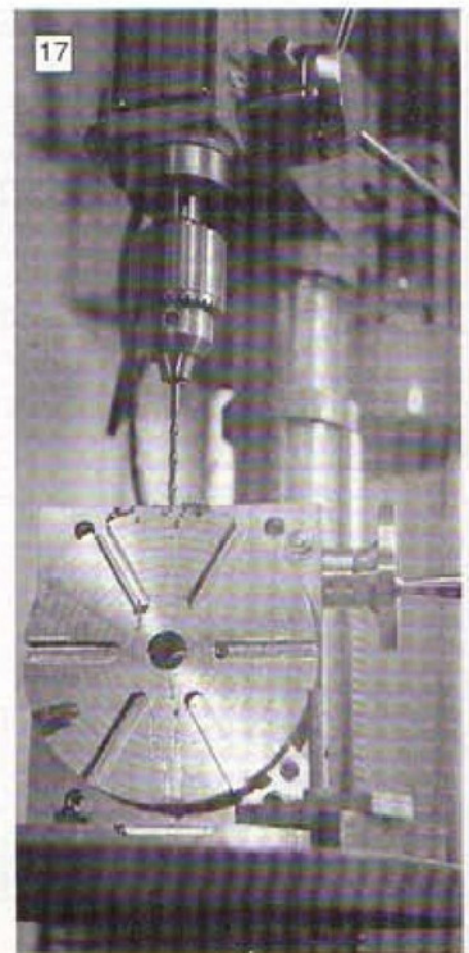
Check & remove all sharp corners & burrs.

Heat the table in the domestic oven at 250deg. C for about 2hrs, standing on three spacers, so that the pin can protrude. If possible put the pin in the freezer or at least the ice compartment of the fridge. Don't blame me if the 'domestic authorities' or 'er indoors' rebel, but this is the best way of evenly heating the table.

When the table has turned blue/brown,

wearing gloves, whip the pin out of the freezer and insert it in to the table in **one movement**. Don't 'try it'; the pin will expand and stick part way. Ensure that the pin is right down on its seating. Leave to cool naturally, don't quench it. This will reduce any distortion to a minimum.

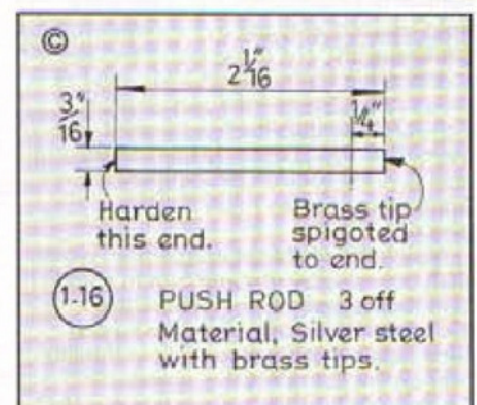
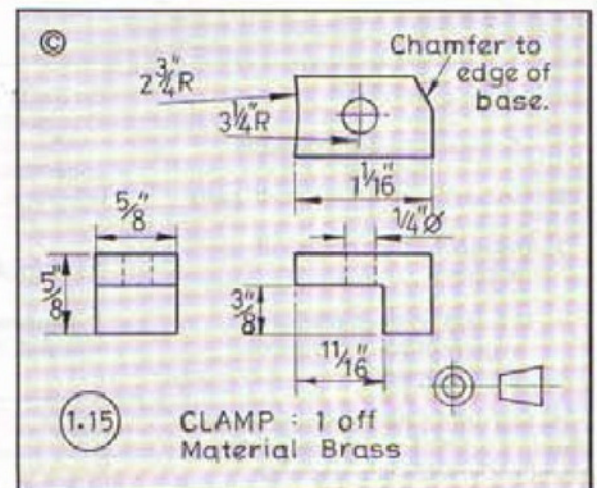
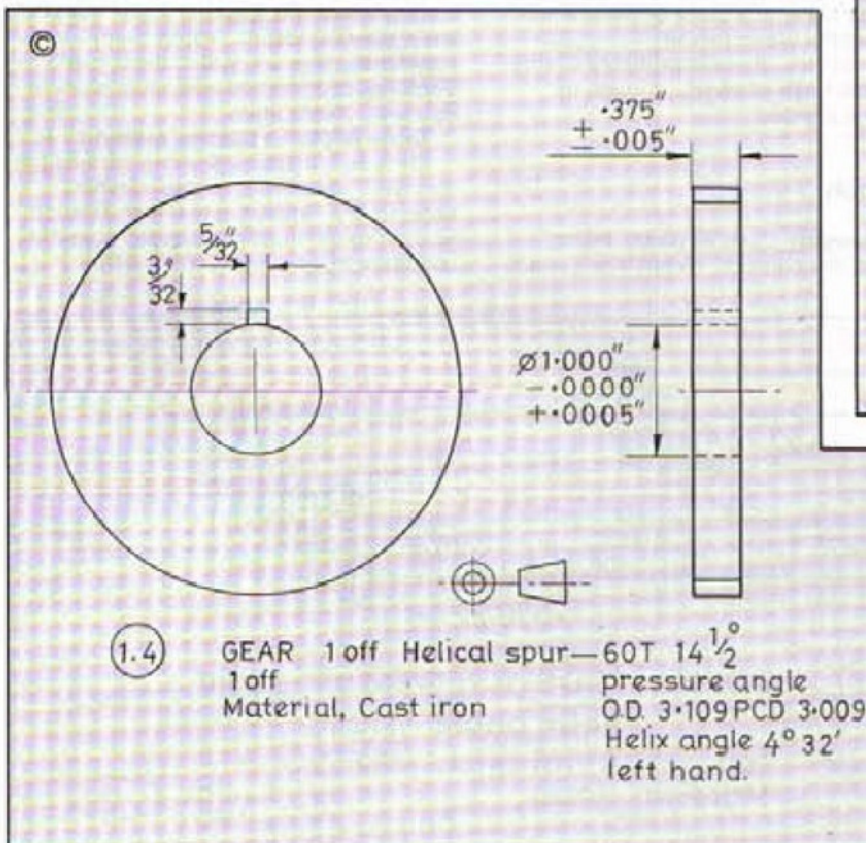
If the pin does stick, I'm sorry, but the only remedy is to machine it out and try again. I would **not** advise pressing the pin out, as you will probably tear the bore and distort the table. It is for this



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reason that the Loctite method is offered as an alternative.

Assemble the table and base, oiling all



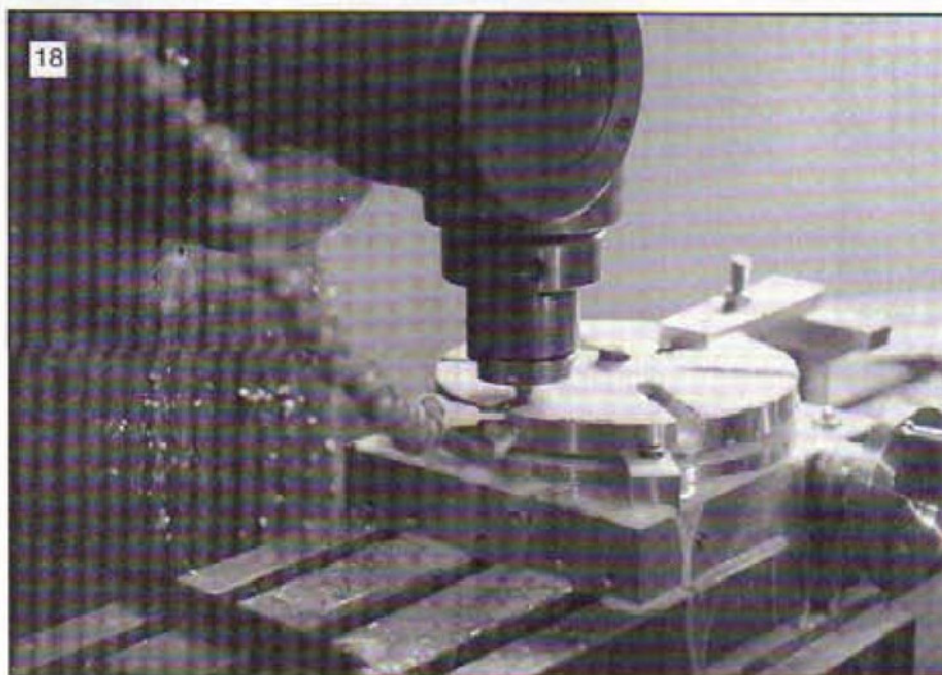
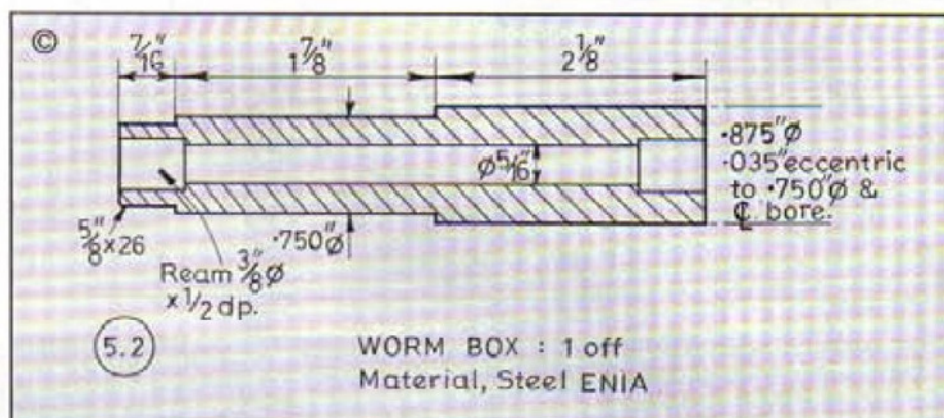
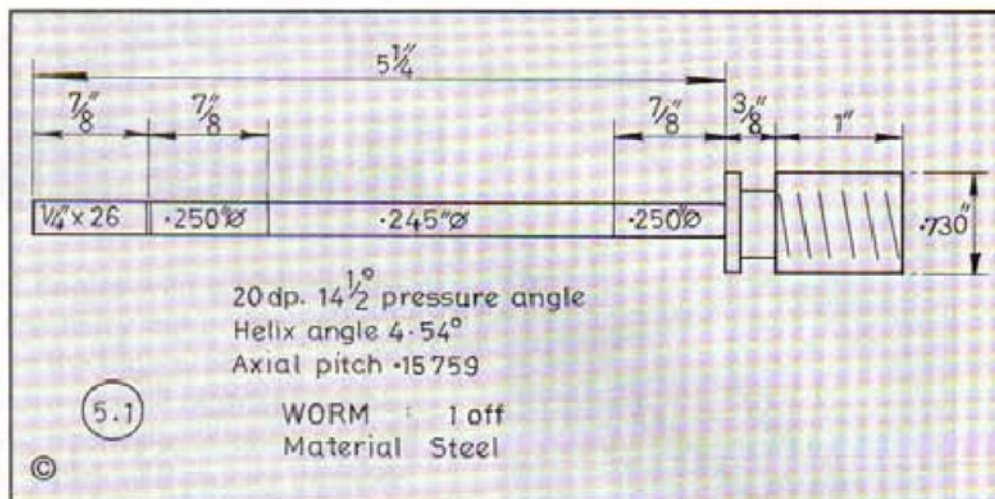
mating surfaces. Fit the key and gear with the nut(1.5) (recess to gear) and check that the table rotates smoothly, then lock up tight with the nut and nip the pinch screw.

Using studs, set up on the faceplate, clocking dead true to the centre bore and take a final facing cut across the table, marking the setting rings at 0.2in. increments if desired: **Photo 16**.

Note: When using the heat shrink method, it is possible the bore will close up because of the massive pressure exerted by the contraction (mine did by over 0.0015in.). This can be rectified at this stage with a boring tool.

Worm & wormbox assembly

Fit the thrust race, wormbox, thrust race etc. to the worm. The thimble is slipped over the nut with a bit of 0.030in. dia bronze or hard brass wire about 2/3rds the circumference, to act as a friction spring. Screw on to the worm, with a short copper pad (bit of rivet?) under the grub screw; adjust the end float to zero (you can preload it lightly), and tighten the grub screw. Fit the handle and nut, locking up tight with a pin spanner. The worm can now be slid into its bore and the eccentric used to adjust the backlash.



Slots/holes etc.

I cut 6 radial 'T' slots, 'Myford' size, or you can drill & tap holes as per the drawing. TIP: if you are cutting 'T' slots, use a new or really sharp slot drill and lots of coolant, not because of heat, but to wash away chips to prevent the cutter jamming, the most common cause of 'T' slot 'difficulties'. **Photo 18**.

Finals

Strip, carefully clean, plug the three tooling holes in the underside of the base with 1/4in. BSF x 3/8in. grub screws, fill the rest of the same holes with discs of felt and reassemble, setting the nut (1.5) so there is no play, but not too tight. Force oil in the lube port and plug with a grub screw.

Cut a disc of 18swg steel to fit the 4in. dia recess and fix with small countersunk screws.

Versatile dividing head gear for 5/8in. Rotary table

If you have got this far, this bit isn't going to present many problems, so just a brief description of a few points to notice.

Item 5.1 Worm

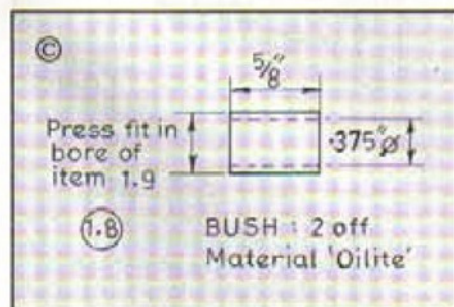
As for the main worm, but take care with the very slender shaft.

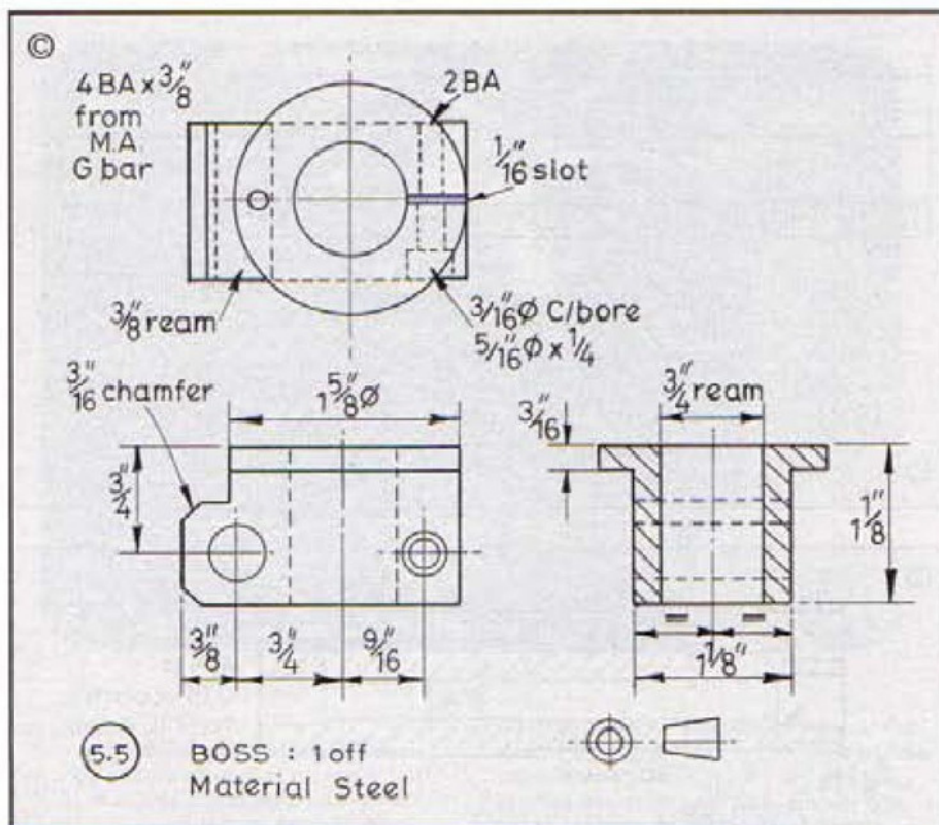
Item 1.15 clamp

Machine from brass. Spot through to drill & tap the base 1/4in. BSF and fit.

Item 1.16 Push Rods

Set up and drill the table, counterbore & tap, using the worm to index the positions. Check the pins for length (i.e. screws below flush): **Photo 17**.





Item 5.2 Wormbox

Turn the 0.750in. dia to gauge on the 'micro attachment' worm gear. Turn and screwcut $\frac{5}{8}$ in. x 26 TPI to gauge on the retaining nut from the V.D.H. The eccentric part, 0.035in. (0.070in. T.I.R.) can be turned by setting in the 4 jaw. I found it best to drill the hole from either end, boring and reaming the 'Oillite' bush seats.

Item 5.5 Boss

Square up, mark out, set in the 4 jaw, centring off the $\frac{3}{4}$ in. dia running true, face, drill and bore to gauge on the wormbox. Turn the $\frac{15}{8}$ in. dia.

Set up on an angle plate on the faceplate to drill, bore and ream the $\frac{3}{8}$ in. dia bore, then the rest of the sides can be milled away and slit etc. I clamped it to a mandrel to face to thickness. This leaves the boss free to rotate to any convenient position when using the table where it can be locked with the 2BA Allen screw.

Assembly

Much as for the table, except that I used graphite grease instead of oil and was very careful to set the end float, as there are plain thrust faces.

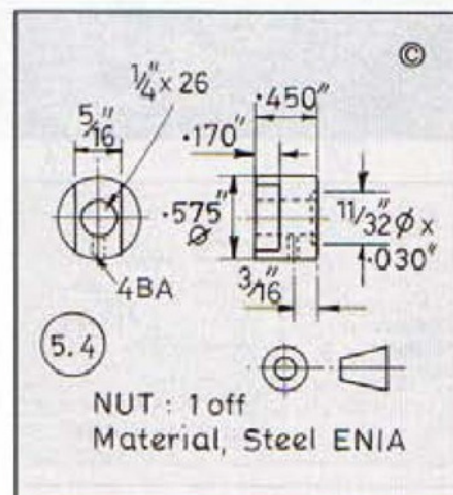
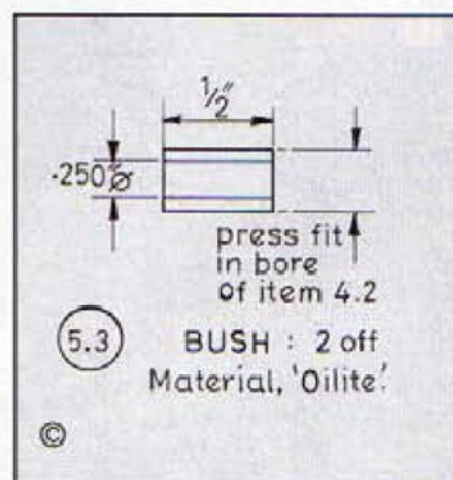
Materials List

Item No.	Sizes to finish in inches
1.1 Base	1 off 6 x $1\frac{1}{2}$ x $6\frac{1}{2}$ BMS
1.1a Foot	1 off $2\frac{1}{4}$ x $\frac{3}{4}$ x 6 BMS
1.2 Table	1 off $5\frac{7}{8}$ x $1\frac{1}{8}$ EN1A
1.3 Pin	1 off $1\frac{3}{4}$ dia x $2\frac{5}{8}$ EN1A
1.4 Gear	1 off 60T Helical spur C.I.
1.5 Nut	1 off 2 dia x $\frac{5}{16}$ EN1A
1.6 Worm	1 off To match gear (1.4) BMS.
1.7 Thrust Bearing	2 off $\frac{3}{8}$ bore x 0.8 needle roller with washers (Part Nos. NTA 613 & TRA 613)
1.8 Bush	2 off Oilite $\frac{1}{2}$ x $\frac{3}{8}$ x $\frac{5}{8}$
1.9 Wormbox	1 off $1\frac{1}{4}$ dia x $2\frac{1}{4}$ EN1A
1.10 Sleeve Nut	1 off $1\frac{1}{4}$ dia x $\frac{3}{4}$ EN1A
1.10a Thimble	1 off $1\frac{1}{4}$ dia x $\frac{3}{4}$ EN1A
1.11 Handle	1 off 3 dia x $\frac{3}{4}$ EN1A
1.12 Nut	1 off 1 dia x $\frac{1}{4}$ EN1A
1.13 Handle	2 off $\frac{1}{2}$ dia x $2\frac{1}{8}$ EN1A
1.14 Pad Bolt	1 off $\frac{5}{8}$ dia x $2\frac{1}{8}$ brass
1.15 Clamp	1 off $\frac{5}{8}$ sq. x $1\frac{1}{8}$ brass
1.16 Push rod	3 off $\frac{3}{16}$ dia x 2 silver steel with brass tips
1.17 Bolt	6 off $\frac{1}{4}$ BSF x $1\frac{1}{4}$ Allen capheads
1.18 Screw	1 off 4 BA x $\frac{3}{16}$ Allen grub
1.19 Nut & washer	1 off $\frac{1}{4}$ BSF hex steel
1.20 Dowel	2 off $\frac{1}{4}$ dia x $1\frac{1}{4}$ silver steel
1.21 Bolt	4 off $\frac{5}{16}$ BSF x 2 Allen caps, cut to fit for bolting down
1.2 Screw	4 off $\frac{1}{4}$ BSF x $\frac{3}{8}$ Allen grub

V.D.H. attachment

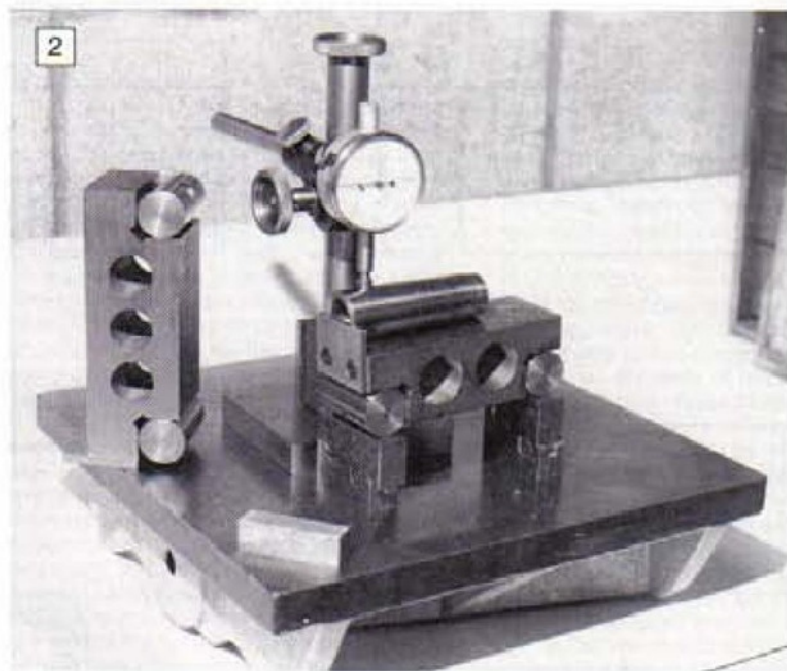
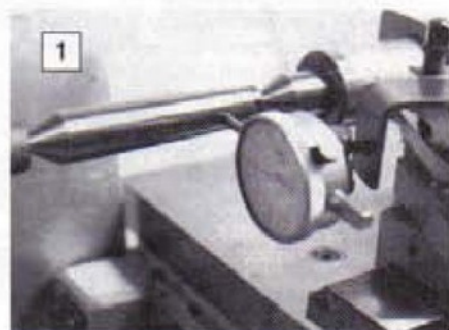
5.1 Worm	1 off	To match gear (1.4) BMS
5.2 Wormbox	1 off	1 dia x $4\frac{7}{16}$ EN1A
5.3 Bush	2 off	Oilite $\frac{3}{4}$ x $\frac{1}{4}$ bore x $\frac{1}{2}$ long
5.4 Nut	1 off	$\frac{5}{8}$ dia x $\frac{1}{2}$ EN1A
1.5 Boss	1 off	$1\frac{5}{8}$ sq. x $2\frac{1}{8}$ BMS
1.6 Screw	1 off	4 BA x $\frac{3}{16}$ Allen grub
1.7 Screw	1 off	2 BA x 1 Allen cap

The materials for this rotary table, including the gears and bearings are available from N.S.&A. Hemingway, 30 Links View Half Acre, Rochdale, Lancs. OL11 4DD Tel.01706 45404. Kit Ref. H106.



MORE ANGLES ON THE SINE BAR

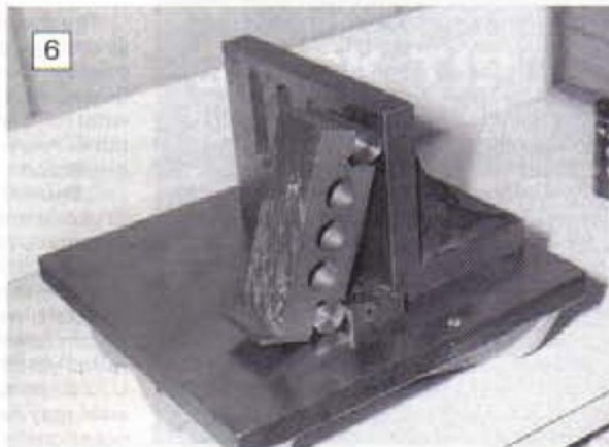
The measurement and setting out of angles with a high degree of accuracy is one of the trickier tasks to carry out in the home workshop. Few of us have access to the high precision equipment which facilitates the process, so Bill Morris describes the characteristics of the instruments involved and gives us clear instruction on how to produce a set which will greatly increase our workshop capabilities.



- 1: Setting top slide angle from external taper.
- 2: Measuring external taper on sine bar.
- 3: Setting straight edge on cross slide parallel to lathe axis.
- 4: Setting top slide angle from sine bar.
- 5: Detecting lobing.
- 6: Setting angles greater than 45 degrees.

Harold Hall's excellent article, *Measuring and Marking Out Angles* in issue 24 of *MEW* came at a time when I had been pondering one of the more interesting ways of setting out and measuring angles, by the use of angle gauge blocks, and I had made a start on making some. Harold thinks that it is unlikely that accuracy of better than two minutes of arc would be required in a home workshop. Until a year or two ago I would have agreed with him, but since taking a deeper interest in precision measurement, two minutes now seems to me to be rather a large quantity! When trying to make the angle blocks, I found that I had to rely on the accuracy and precision of a rotary table. The

manufacturer's inspection certificate guaranteed a maximum cumulative error of 1 minute or around 0.005%. The collar on the handwheel is graduated in single minutes with subdivision by Vernier to 10 second intervals. However, the accuracy of the finished product would be unknown and, really, use of a sine bar is the only easily made fundamental method of measuring the angles with a maximum probable error that can easily be calculated. It is also an extremely useful



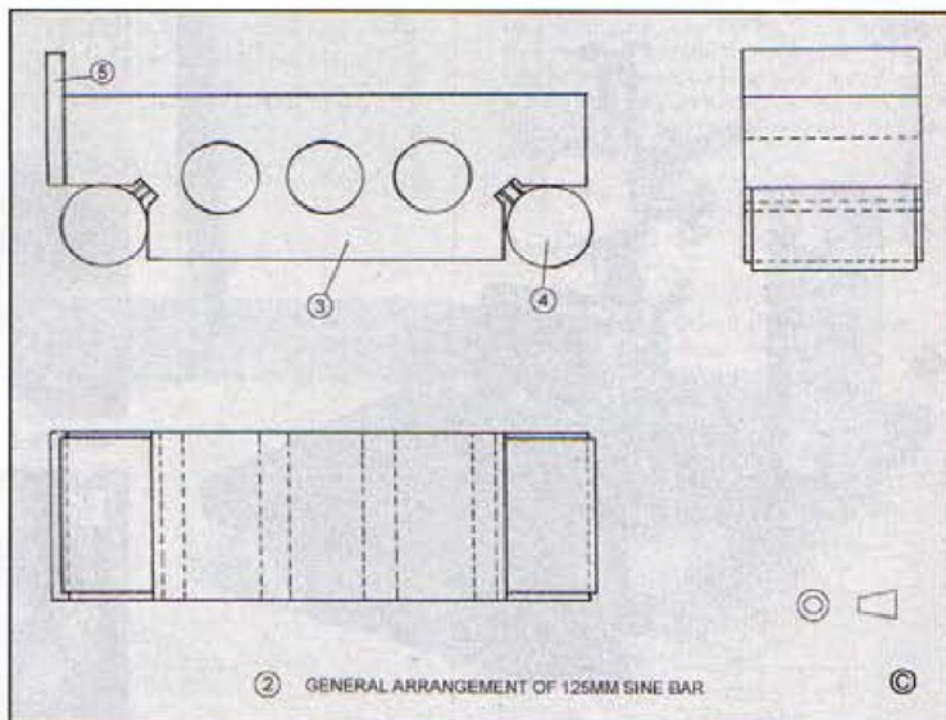
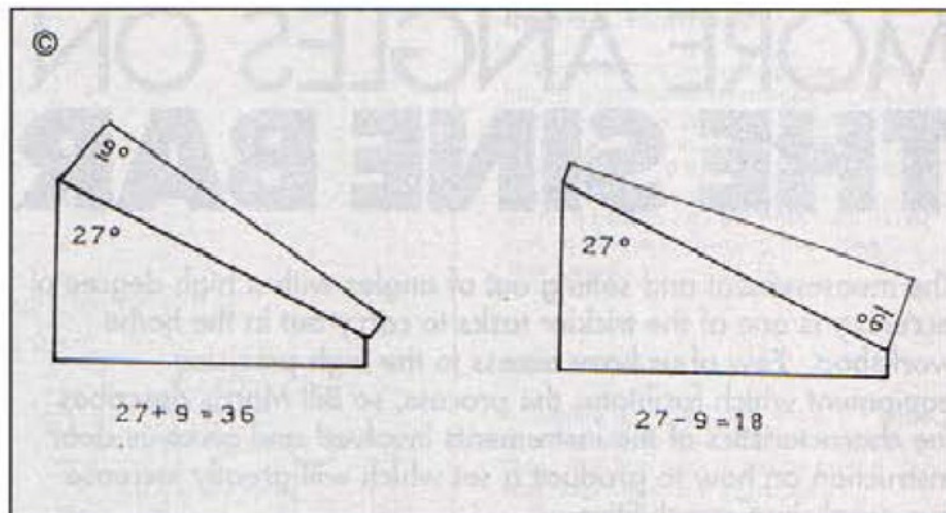
method of setting the lathe topslide to produce tapers that will fit first time. Making a useful sine bar is not quite so easy and I will analyse the potential errors, but first a digression on angle gauge blocks to complete the discussion that Harold began.

Slip gauges can be used only additively to increase the length of a pile of gauges. It may surprise you to learn that since angle gauges can be used subtractively as well as additively (Fig. 1), with only thirteen gauges, one of them a square block, any angle can be set up with an uncertainty of only three seconds, to an accuracy of better than one second. With ten blocks the precision is thirty sec.. Table 1 shows the values required and Table 2 some examples of making up the angles. Commercial gauges have the faces lapped to a wringing finish like those of slip gauges, but this would be beyond most amateurs including, so far, myself. However, producing a ten gauge set, accurate to within a minute and held in a simple holder, may well be possible for some, provided some means of setting up the angles is available, and this is where a well made sine bar comes in. (Fig. 2).

Even for those with no interest in making the gauges, a sine bar can be used to copy an unknown taper or to set up a known one. When I recently acquired a dividing head of Japanese manufacture, I found that the spindle taper did not correspond to any in *Machinery's Handbook*. The previous owner had made a taper socket for No. 2 Morse taper that fitted nicely, but when I checked, I found that the 2 MT hole was not concentric with the outside. Normally, one would set up the socket between centres in the lathe and set the top slide angle using a dial test indicator as shown in Photo 1, but this method was not open to me as the socket was slightly eccentric, so as this article was in embryo, I turned to the sine bar method.

Slip gauges are very expensive. Length tolerances for Grade 1 sets, those used as a general purpose manufacturing gauge, are about ± 0.0005 / ± 0.0003 mm. With a micrometer in good condition, it should be just possible to measure to ± 0.002 mm. Now one could use a bottle jack as suggested by Harold Hall, but it would have to be an exceptional jack for the top surface of the screw to be truly parallel with the base and so I resolved to make some adjustable parallels which should give much better accuracy.

Photo 2 shows the socket set up on a sine bar with the difference in height of the two adjustable parallels (about which more later) set until the DTI shows no change in reading when run along the top of the taper. The heights of the two parallels are then measured and the higher one reduced by half the difference in height (fortunate owners of slip gauges will of course use them). Next, a straight edge is clamped to the top of the lathe cross-slide and set parallel to the lathe axis using a DTI from the lathe bed (Photo 3). The sine bar can then be set on its side with the parallels set between the rollers and the straight edge and the top slide set from the top (now front) surface of the sine bar (Photo 4). If the taper angle is known, the height difference can be calculated as in Sketch 1 of Harold's article



and I give in Table 3 the included angles for Morse tapers with height differences for half the angles to use with 5 inch and 100mm sine bars for those whose maths is perhaps a little shaky.

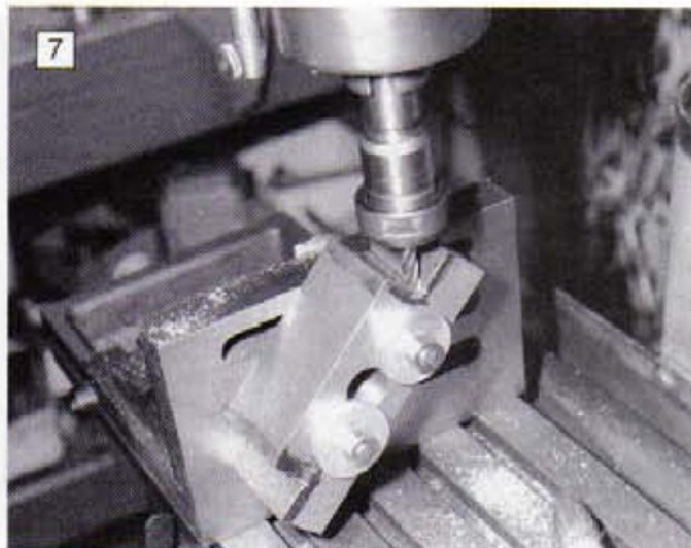
Sine Bar characteristics

The accuracy of a sine bar depends on several conditions, some of which are easy for the amateur to achieve and some of which are far less easy, depending on what tools are available. The situation is rather more complex than in Harold's brief discussion.

Equal size of rollers is relatively easy to obtain and for the amateur, two pieces of round silver steel cut from the same bar are likely to be of equal diameter within closer limits than most amateurs can detect. However, silver steel is produced by centreless grinding and may not be round yet be of constant diameter, like a U.K. 20 pence coin. Centreless-ground steel may have three, five and occasionally seven or even nine lobes. A

micrometer cannot detect out-of-roundness of this sort. Photo 5 shows how to detect lobing, by rotating the roller in a vee block and checking that the DTI reading remains constant. The piece of 1 1/4in. diameter bright drawn mild steel shown had a diameter constant to within 0.005mm, but was irregularly lobed to the extent of 0.03mm. Using it would have introduced a significant uncertainty, whereas the piece of 1in. diameter silver steel that I used in my sine bars had no measurable variation in diameter and only 0.003mm out-of-roundness, almost within BS3064 : 1959 tolerances for roller diameter equality. Nominally of one inch or 25.4mm, it was as nearly as I could measure it 25.39mm in diameter.

It is relatively easy to ensure that the roller centres are of equal distance from the top surface of the bar by machining the top surface as the last operation with the rollers resting on the table of the milling or grinding machine. This does not eliminate errors introduced by movement of an imperfect machine table, but these can be almost completely eliminated by



7: Milling seat for roller screw.

spot grinding, as you will see later. A related problem, that of ensuring that the roller axes are parallel with the top surface of the bar and hence with each other in the horizontal plane, is taken care of at an earlier stage by careful machining. Any error in parallelism will declare itself by the bar rocking on its rollers when resting on a surface plate. Upper surface out-of-flatness has the effect of introducing parallelism errors, but by spot grinding it should be possible for the amateur to equal or exceed the standard of $\pm 0.0013\text{mm}$.

I found that the most difficult condition to ensure with machinery available to the amateur is parallelism of the roller axes in the vertical plane. An error here means that the higher of the rollers will rest on the gauge block at only one end. This point contact might not matter, except that it then becomes very difficult to measure the distance between the axis of the lower roller and the centre of the circle represented by the end of the upper bar. If I were making another bar, I might choose the 'hook' design rather than the symmetrical shape because with the former, parallelism is easier to achieve. Unfortunately, it is also extremely difficult for the amateur to determine the centre distances with sufficient accuracy with this design.

The actual distance apart of the roller axes is unimportant, provided that it is known accurately. In the days before electronic calculators, lengths like 100mm or 5 or 10 inches were chosen because these were easy to divide and multiply by. Nowadays, a pocket calculator makes mincemeat of what were once laborious calculations, so it is no hardship to have a sine bar of, say, 99.97mm. Actually, measuring the separation of the roller axes will be difficult for amateurs and most will have to rely on measuring the diameter of the rollers with a micrometer and then measuring over the rollers with a Vernier calliper. If the measuring faces of a newish micrometer are carefully cleaned and its error noted when measuring a standard bar of length similar to the roller diameter and if the instrument is closed slowly on a carefully cleaned workpiece until the ratchet gives one click, it may by

repetition and averaging of measurements be possible to estimate the roller diameter to within perhaps 0.005mm or 0.002in., but I would never swear to it. The absolute limit of accuracy of a Vernier calliper is, however, 0.02mm or 0.001in. and careful reading with a magnifying glass may be needed to achieve this. This is about 10 times worse than BS 3064: 1969 for roller centre distance.

In summary, with our amateur's bar we cannot rely on the separation of the roller axes to an accuracy of better than 0.02mm. We cannot rely on the height of the packing blocks to much better than 0.005mm if measured by micrometer; and if we detect out of parallelism of the roller axes in the vertical plane, we should prefer the shorter length as the best estimate of roller separation. We cannot really eliminate lobing of rollers as a source of error unless we can get someone to grind them on dead centres for us, so we should add this to the probable error of packing block height and say that the total height error is of the order of 0.01mm.

As mathematicians are fond of saying, it can be shown (by the method of partial differentials) that the error, dA in an angle A , set up with a packing of height H and roller centre distance L , is as follows:-

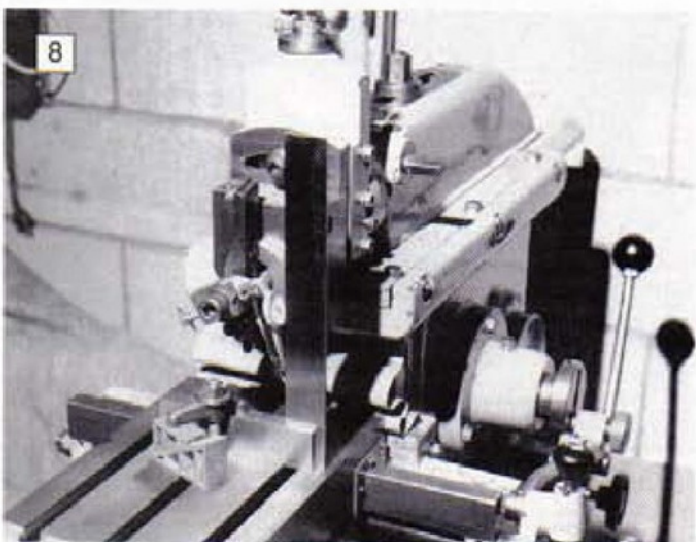
$$dA = 1/L(\sec A dH - \tan A dL) \\ (\sec A = 1/\cos A)$$

where dH is the packing block error and dL is the centre distance error.

The error dA (in radians) is at a maximum when the errors are of opposite sign. Thus for our home made sine bar set at 45 deg., the maximum error is likely to be about 0.00034 radians or 70 sec., about ten times worse than using a commercial sine bar with slip gauges. By contrast, if one were laying out an angle of one minute, the error would be about 10 sec., a much smaller absolute error, but a much greater percentage error.

The errors increase very rapidly beyond about 60 deg. and in practice, angles greater than 45 deg. are set up by calculating the block height for the complement of the angle and setting it off from an accurate 90 deg. angle plate, as shown in **Photo 6**.

8: Setting tool slide square to table.



Making the Sine Bar

Commercial sine bars are made from steel hardened to at least 60 on the Rockwell C scale, but since the amateur is unlikely to be able to harden large lumps of metal successfully and still less be able to surface grind the result, he is better sticking with mild steel. You will see from the photographs that I made two bars, one of 100mm centres and one of 125 mm. If you make yours from a piece of anonymous scrap, have a very careful look at it before commencing — this advice is borne of bitter experience. I drilled the lightening holes as almost the last operation and discovered that one of them was progressing, though not very easily, through a weld. My lesson learned, I then visited the local steel factor and bought a bar end of commercial grade mild steel, 50 mm square, for my second attempt.

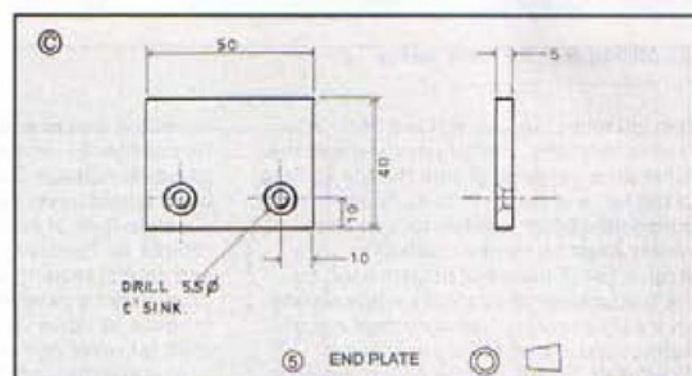
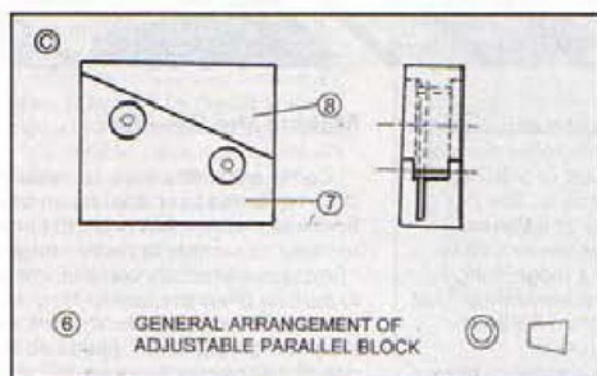
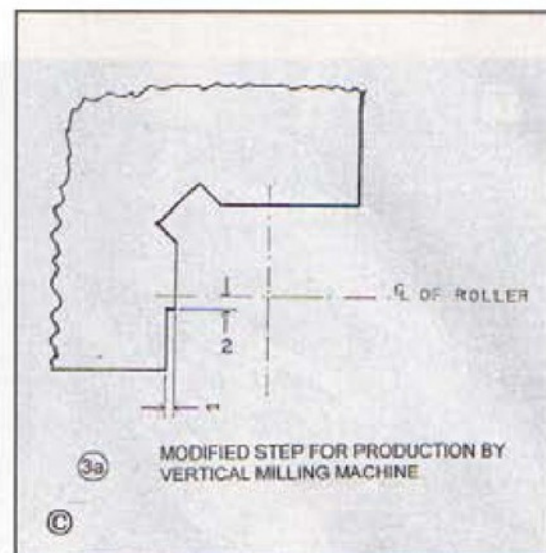
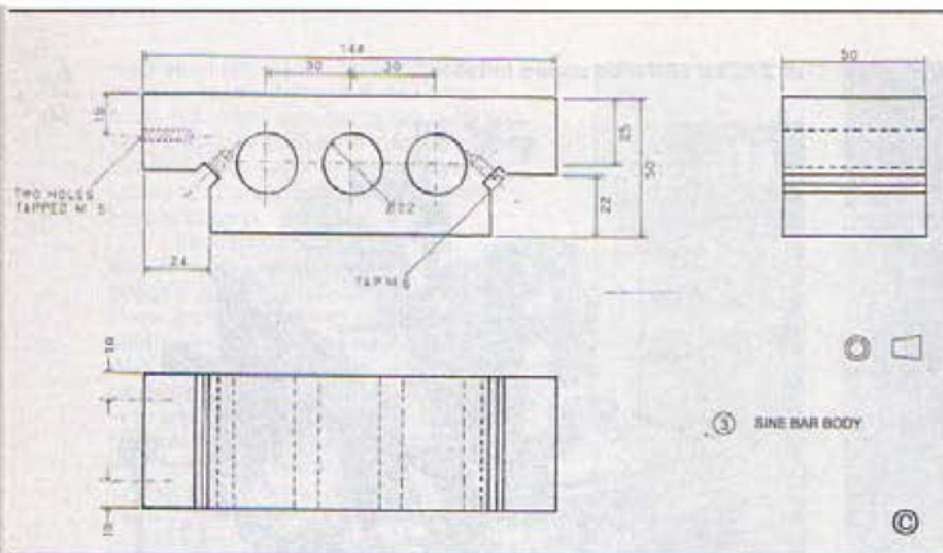
So, having cut off your chosen piece of steel roughly to size, square the ends. If you have a fairly large lathe the bar can be held in a four jaw chuck and faced quite quickly, albeit a little precariously. Most mill-drills would have the capacity to flycut the ends with the bar clamped vertically to an angle plate or it could even be clamped to the cross slide of your lathe and fly milled. Then mark out the blank (**Fig. 3**) to your preferred size and drill the large

QUICK TIP

Stainless steel wire

A good source of stainless steel wire (approx. 0.025in. dia), useful for suspending articles in an acid bath, hanging them up when spray painting, or for wire locking bolts, is MIG welding wire, obtainable from a welding stockist.

G. Hugh Dawkins

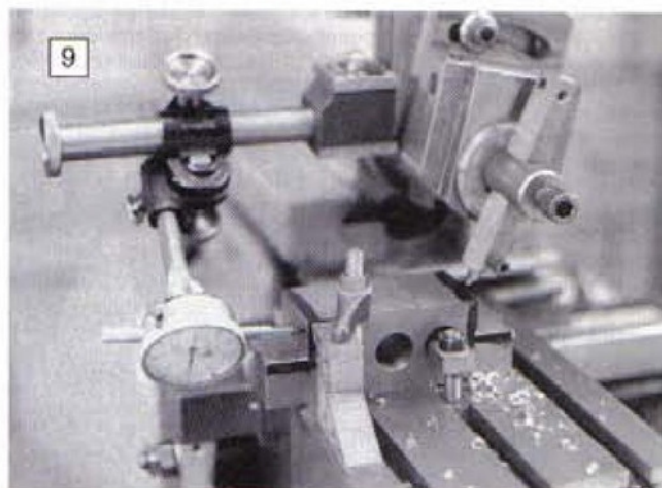
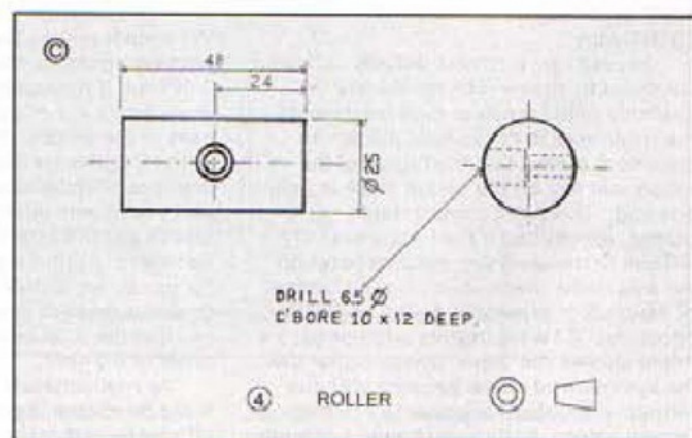


QUICK TIP

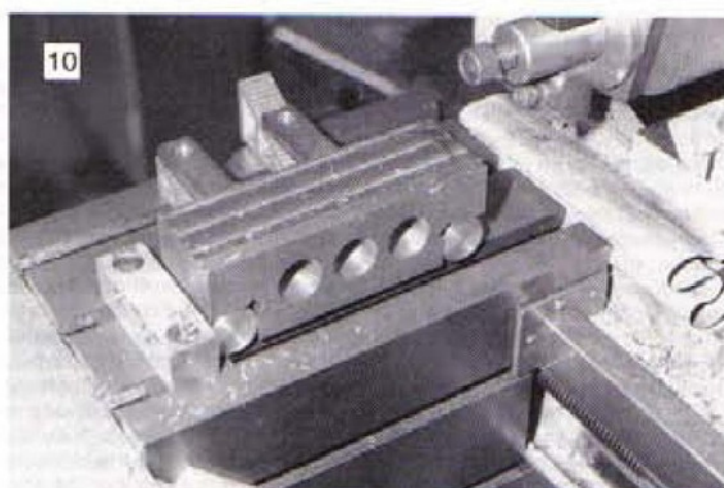
Millimetres to inches

The indexing collars on my lathe and milling machine are engraved in increments of 0.025mm. This used to confuse me when working in inches, until the great truth struck me that 0.025mm = 0.0009843in. I now consider that each increment is one 'thou', and life is much simplified.

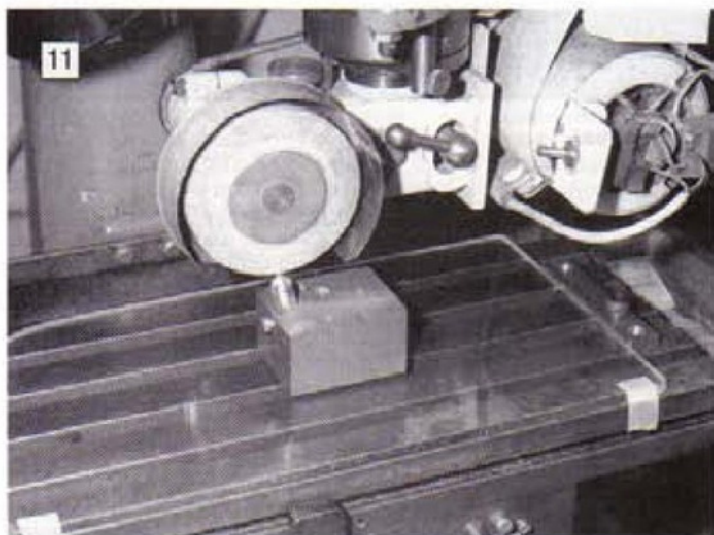
Hubert Elffers



9: Setting up for second step.



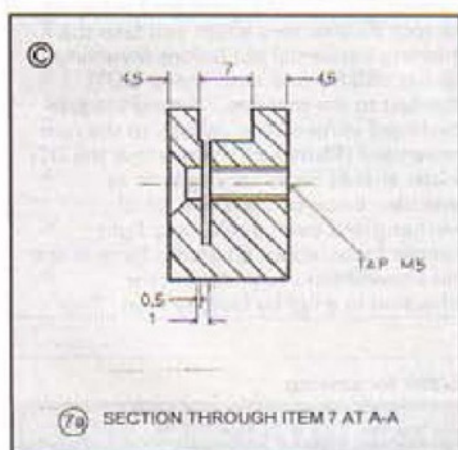
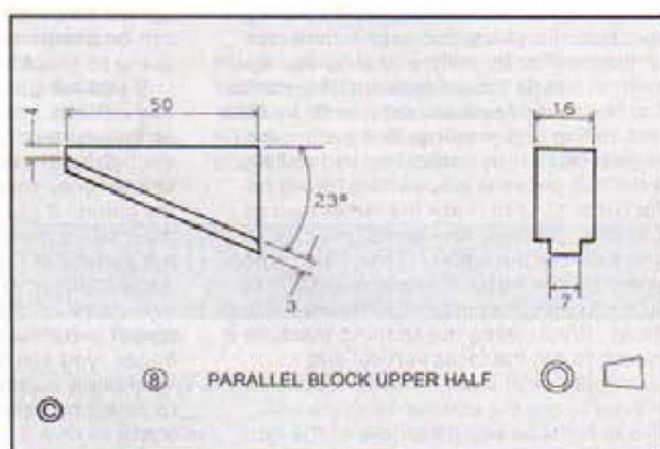
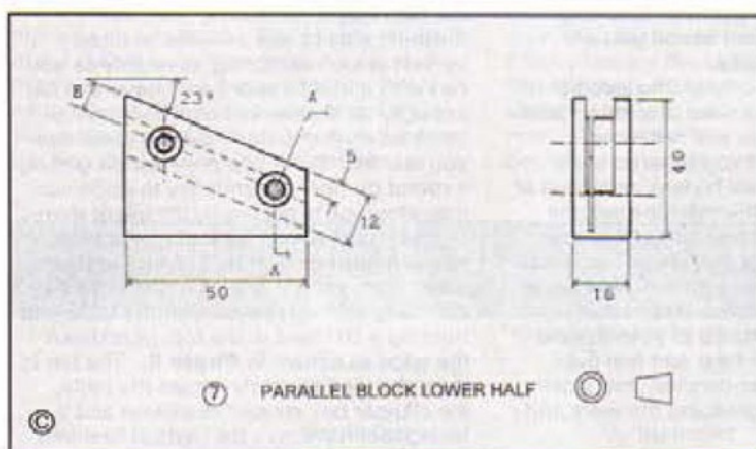
10: Shaping top of sine bar.



11: Truing grinding wheel.



12: Holding large pieces for spot grinding.



holes which are partly to lighten the bar, partly to provide a means of bolting it to an angle plate when in use and partly to allow it to be held to the machine table when making it, something that did not occur to me when making the first version. Most of us will not have a drilling machine robust enough to drill these large holes and will have to clamp the job to a faceplate to drill and bore them to size in the lathe. Don't forget a counter weight unless you like to see your lathe shake itself to pieces.

If you have a band saw that can be set in the vertical mode, the steps can be cut from the end with the minimum of labour, or you can set to with a hacksaw. It is not on the whole a good idea to end mill away

QUICK TIP

Using epoxy or polyester resin.

Warm both the resin and hardener on a radiator before mixing. The mixture needs to be warm and dry for best results and the resin will pour more easily.

W.J.R.H. Pooler

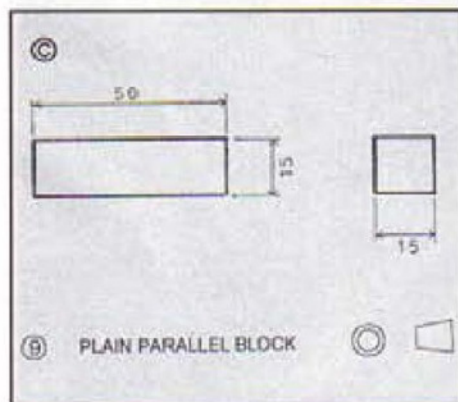


Table 1

Angle gauge values						
Degrees	1	3	9	27	41	90
Minutes	1	3	9	27		
Seconds	3	6	18	30		

Table 2

Angle Gauge Examples

23deg.	+27deg.	-3deg.	-1deg.		
38deg.	+41deg.	-3deg.			
45deg.	+41deg.	+3deg.	+1deg.		
35deg. 18min. 42sec.	+27deg.	+9deg.	-1deg.	= 35deg.	
	+27min.	-9min.		=	18min
	+30sec.	+18sec.	-6sec.	=	42sec.
				35deg	18min. 42sec.

the large chunks of metal, as it needlessly uses up the life of your expensive cutter as well as being tedious. It is much cheaper, though at least as tedious, on a shaping machine. Finishing the steps to size can be done either by milling or shaping. Each method has its advantages and drawbacks. The horizontal faces are easy to do by both end milling and shaping, but getting the vertical faces truly vertical by end milling is difficult because side cutting forces on the cutter tend to make the cutter lean to one side, taking a heavier cut near the shank end of the cutter. Good finish when using the side of an end mill is difficult to obtain unless the cutter is well-centred and sharp. When using the shaping machine it is easy to get the faces vertical and horizontal, with a good finish, but more difficult to get the vertical faces parallel. This is because any looseness of the ram in its ways and of the tool box in the tool slide will act in opposite directions when the right and left hand vertical faces are machined, effectively doubling any errors. The problems with either method can be minimised at the cost of some complication, but making a useful sine bar is not altogether the simple exercise it appears.

If you plan to mill the step, the initial stages have to be a little different. Having marked out the step and cut it nearly to size, set up the bar at 45 deg. on an angle plate (**Photo 7**) or in a milling vice and

mill the seat for the roller screws with an 8 mm or $\frac{5}{16}$ in. end mill. While you have things set up, you might as well drill and tap the holes for the screws. This stage can be postponed until later if you are going to shape the step.

If you are going to finish the step by end milling, you will need at least a 12mm or $\frac{1}{2}$ in. cutter, or you will not have enough reach; and if you have an even stouter one, there will be less deflection of the cutter, if not of the machine column. Start by cleaning off any burrs from the top surface of the bar and check that it sits flat without any rocking on a surface plate. If you sit it on the plate and rap each corner in turn with the tip of your middle finger, you can both hear and feel even very slight rocking tendencies, too small to detect by simply grasping the work and trying to rock it.

Clamp the bar directly to the machine table; the lightening holes make this easier to do without the clamping paraphernalia getting in the way of the milling chuck. The long axes of the table and bar should coincide, and it is worth using a DTI to do this, rather than relying on the edge of a tee slot as a datum. The horizontal faces of the steps are very straightforward. Simply end mill them at the same setting and, barring error in the longitudinal slideways of the machine, they should be parallel and in the same plane. To do the vertical faces, start by

side milling relieving steps almost down to the future centres lines of the rollers (**Fig. 3a**) to give the cutter less work to do on the face where it matters, then take finishing cuts to size over the reduced vertical area, measuring as closely as you can with a micrometer if you have one big enough, or Vernier callipers if you haven't. Don't worry if you don't get the exact size you wanted, but if you are keen on getting a round number, a tendency to undersize may allow you to get one by the use of shims.

If you plan to use a shaping machine, you will need to start by setting the tool slide travel at right angles to the table by clamping your best square to the table and running a DTI held in the tool post down the edge as shown in **Photo 8**. The bar is then clamped squarely across the table, the clapper box rotated clockwise and a facing tool run down the vertical face and out across the horizontal face to the marking out. Set the graduated collar on the tool slide to zero when you take the finishing horizontal cut before reversing the bar end for end and, using a DTI attached to the tool box, setting the just-machined vertical face parallel to the ram movement (**Photo 9**). Notice that the DTI holder should be as stoutly-built as possible, because there is a lot of overhang and even a relatively light plunger force (about 50 grams force in the one shown) can cause significant deflection in a lightly built system. This



13: Holding small pieces for spot grinding.

14: Holding parallel block blank for sawing.



means of course that an error of parallelism will not be detected, as the error is absorbed in the deflection of the system. Clamp firmly, recheck for parallelism and take the finishing cuts down and across the second step, finishing the horizontal face at the previously-set zero setting.

It is possible to take much finer finishing cuts with a shaper compared to a vertical milling machine, but, as in a lathe, the accumulation of clearances in slides, deflections in machine and workpiece parts and variation in oil-film thickness makes working to closer tolerances than 0.02mm or 0.001in. more a matter of luck than skill. Even those tolerances are several times better than what is acceptable in commercial production turning.

If you haven't already drilled and tapped the screw holes, they should be done at this stage. Making the rollers (Fig. 4) is very simple. Just cut pieces of silver steel bar and face the ends in the lathe, using soft aluminium or copper packing so as not to raise any burrs. The precise length of the rollers is unimportant, except that they should not be longer than the bar is wide. Cross drill and counter bore for the fixing screws and before attaching them to the bar, measure their diameter as

carefully as you can with your best micrometer. Start by cleaning the rollers with white spirit and set them end up on a piece of kitchen tissue to dry. Clean the measuring faces of the micrometer in the same way. Slowly and carefully bring the faces together until the ratchet gives one click. Note the zero error at this point. If you have a standard bar of similar length to the roller diameter, it is perhaps worth checking the error of your micrometer at this length instead. Take several measurements over the rollers, bringing the measuring faces up to the work slowly and aiming for one slow click. The average of these measurements is your best estimate of the rollers' diameter, but there is no point in expressing it to nearer than 0.002mm or 0.0001in.

Make sure there are no burrs or sharp edges in the vicinity of the steps and attach the rollers, nipping up the screws quite firmly but not hard. Check that it does not rock on its rollers on a surface plate and if it does, remove the rollers and look for burrs or stray particles. You then attach the bar to the machine table and finish machine the top surface.

Photograph 10 shows the top being shaped after end milling to see which method gave the best equality of distance between roller centres and top. It also

illustrates the use of a stop when holding-down arrangements are not perhaps as good as you would wish. The milling method gave slightly better results and this is the method you should choose if you are not going to finish the top by grinding. Having done the top face, the side faces are finished by taking a finishing cut with the top clamped to an accurate angle plate.

Making and fitting the end plate (Fig. 5) is elementary work and then one can spot grind if need be. The process was described in Issue 20 of *MEW* on page 44, but some revision may be helpful. This is a form of surface grinding that eliminates errors of table movement and gives a surface of superior flatness and parallelism to that obtained by ordinary surface grinding. In the case of the amateur who is unlikely to own a surface grinder, but who may well own a Quorn cutter grinder or a toolpost grinder and a vertical milling machine, the process allows him to produce a ground surface of high quality, not feasible by any other method.

You must devise some way of attaching the grinding head to the quill of the mill, and the quill must be locked against rotation. The wheel **must** be guarded, you **must** wear approved goggles and you should **not** in any case stand in line with

Table 3

Gauge Block settings for Morse Tapers

Morse taper	Included angle (Deg)	1/2 Included angle (Deg)	Height Difference	
			5in. Bar in.	100mm bar mm
1	2.8592	1.4296	0.12474	2.4949
2	2.8632	1.4316	0.12492	2.4983
3	2.8772	1.4386	0.12553	2.5106
4	2.9772	1.4886	0.12989	2.5978
5	3.0166	1.5083	0.13161	2.6322
6	2.9886	1.4943	0.13039	2.6078

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the wheel. That takes care of you.

It is kind to other machines to put on their covers and to the milling machine to cover exposed slides. The periphery of the wheel is then trued from a surface plate resting on the mill table, with a diamond held in a broad-based holder as shown in **Photo 11**. In the photograph I am using a scrap of plate glass because my small surface plate was too small and my large one too large! With a very fine cut, just enough to cause sparking, the surface to be spot ground is moved about by hand under the wheel, systematically covering the whole surface by movement in a variety of directions. It is worth 'exploring' the surface for high spots with the wheel stationary, as to find them with the wheel spinning at 4000 rpm is bad for the nerves to say the least. When all sparking ceases, you put on further cuts until marks from the previous machining process are no longer visible. The resulting surface looks like a finely scraped or galvanised surface, but it is much smoother. It should be flatter too. **Photo 12** shows a small flat being made and illustrates an important point that the fingers should be kept straight as you move the workpiece about, unless you intend to spot-grind your knuckles. Small workpieces should be held lightly in a wire frame or between two small toolmaker's clamps (**Photo 13**) so fingers can be kept clear of trouble.

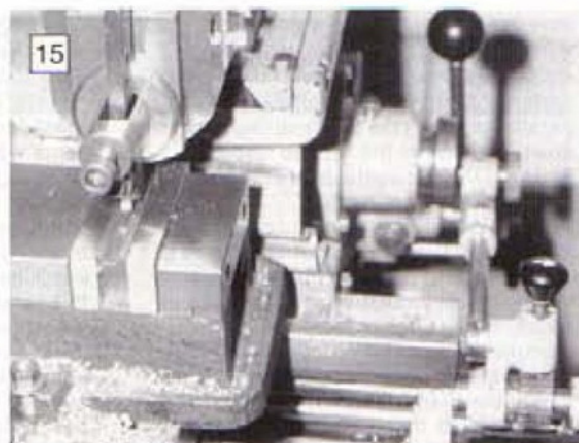
All that remains is to remove all sharp edges, measure over the rollers and subtract the diameter of one of them. Few amateurs will own a micrometer able to measure 125mm, still less 150mm, but if you can borrow one it will give superior accuracy and resolution to Vernier callipers. If you do borrow one, borrow the standard length bar that ought to come with it, so you can allow for zero error. The professional would probably set the sine bar vertically and compare its length with a stack of slip gauges and a sensitive comparator, but he is unlikely to be reading this article, or if he is, is unlikely to learn anything from me. If you have to use Vernier callipers, clean them thoroughly before use and check that the sliding jaw moves freely but without any play. Take an average of several readings, making sure that the instrument is at right angles to the roller axes, and use a powerful hand lens in strong light to read the Vernier. When you are satisfied that you are getting consistent readings, calculate the separation of the roller centres and mark it on the side of the bar.

Adjustable Parallels

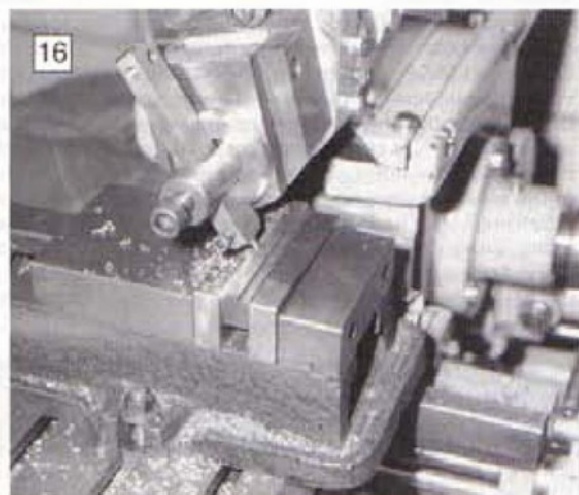
In making adjustable parallels (**Fig. 6**), which I now think of as the poor man's slip gauges, I reckoned that for the 125 mm bar I had chosen, one would not need a height greater than about 90 mm. This gives an angle of just over 45deg., angles greater than this being obtained by setting the complement of the angle off a vertical surface. For small angles, one could use two parallels with the correct difference in height, one under each roller. The dimensions shown in the drawings allow for a practical height variation for each parallel of 35 to 55mm. This allows a range from 35 to 55 and from 70 to 100mm by adding the two parallels. By

subtracting the two parallels one covers 0 to 25mm, leaving two gaps of 15mm to be covered by a single fixed gauge used additively with one of the parallels. I found it convenient to cut two slices off my 50mm square bar end for the adjustable parallels, and a piece of $\frac{5}{8}$ in. square mild steel which cleans up nicely to 15mm for the fixed one. Each face of the square slices is conveniently cleaned by facing in the lathe, holding the work in the four jaw chuck. Each slice is then marked out at 23deg. and sawn at this angle, either by hacksaw, which is hard work, or by bandsaw. In either case, holding the work while sawing is problematical and **Photo 14** shows my solution, in which the fixed jaw of the vice is set at 23 deg., with the blank secured against it by means of a G clamp. If using a shaping machine, the next step is to set the fixed jaw of the machine vice parallel to the ram's movement, using a DTI clamped in the tool post. If you plan to use a milling machine, the jaw must be set parallel with one of the table's movements by using a DTI attached to the milling head. Alternatively, for either machine, the face of an angle plate could be set parallel to a tee slot by abutting against a rectangular bar held against one face of the slot, with the workpiece then being held against the angle plate with G clamps (the hold of toolmakers' clamps may not be secure enough). If you have a choice of shaping machine or milling machine for machining the parallels, the shaping machine will give a better finish on the important surfaces, while a horizontal milling machine will be better than either.

The lower, larger part of the parallel is then marked out (**Figs. 7 & 7a**, lines lightly centre popped, and set up in the vice with the sawn surface set by eye, parallel with the top of the jaw. The groove or mortise is then machined, taking a fine finishing cut down each side, just to split the centre pops when viewed with a hand lens. **Photograph 15** shows this being done in the shaping machine with a stout parting tool, which can be used for both roughing out and finishing both sides of the mortise. Note that the tool box has to be set strictly vertical or the tool will jam on one side or the other. As it is, it will scrape lightly on the return



15: Shaping the mortise.



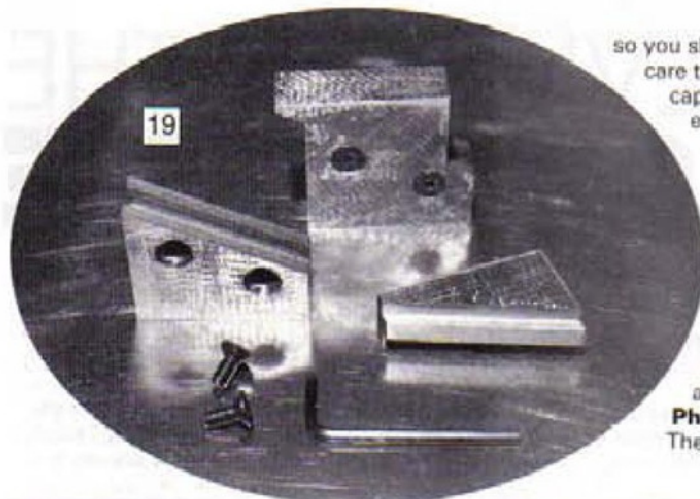
16: Shaping the tongue.



17. Planer gauge.



18: Slitting the blocks in tandem.



so you should take extreme care that they do not capsize and jam. This is especially liable to happen with first cuts if there happens to be a high corner, so always explore for this condition with the wheel stopped and patiently take very light cuts. The finished blocks are shown assembled and anatomised in

Photo 19.
The plane parallel

block (**Fig. 9**) is made simply by spot grinding opposite faces of a piece of square steel and its exact dimensions are unimportant as long as the distance apart of the parallel faces is known.

When you have finished the sine bar and the adjustable parallel blocks, it is worth making a baize-lined box for them to protect the finely finished surfaces from knocks and scrapes. Try not to finger the surfaces as you may tend to cause rusty finger prints. A good practice is to protect the working surfaces with a mixture of white spirit and Vaseline in equal parts after use and to clean them with spirit or filtered paraffin (kerosene) before use.



19: Finished blocks.

stroke, so for the finishing cuts apply a few drops of tapping fluid.

The upper part of the parallel is marked out (**Fig. 8**) and set up in the same way for machining the tongue or tenon. You should aim for this to be a sliding fit rather on the tight side in the mortise. Ensuring that the bottom of the step is at the same height on both sides of the tongue is easy in the milling machine, but more difficult in the shaper, as right and left hand tools have to be used (**Photo 16**). Setting the tools to a planer gauge as shown in **Photo 17**, or even to a stack of packing is the easiest solution to the problem (the gauge shown was made by essentially the same methods, but is for the 'advanced beginner', as it has a dovetailed slot). As long as the tongue is of the correct form and well-fitting, it does not matter whether it is exactly central, as the two parts will be married for cleaning up. If the fit is a little slack, the mortise can be closed by squeezing in a vice, but try a little at a time, as it is a good deal easier to close up when too wide than vice-versa.

The relieving saw cut could be done by hacksaw, but is much neater when done by slitting saw. **Photograph 18** shows this being done in stages on my mill-drill, with the blocks clamped in tandem. Once this has been done, the two screw holes can be drilled, tapped and counter sunk for the clamping screws. Even when clamped, the 23deg. angle is too steep to allow much force to be applied across the (eventually) parallel surfaces without the two parts sliding, so the assembled block has to be clamped across the ends to clean up the vertical faces. This done, the blocks are held as a pair in the vice by the vertical faces and the horizontal faces cleaned up, taking only light cuts. While it is not crucial that they are machined as a pair so that the vertical dimensions are the same, it makes the subsequent spot-grinding a little easier and safer if they are.

Start by spot grinding one face of each parallel. The two parallels are then stood upright on a surface plate and clamped together with toolmakers' clamps, ground face to ground face. You can then grind the top and bottom surfaces in turn to get them flatter and more nearly parallel than by any other machining method. Even when clamped together, the blocks are rather tall in relation to their breadth,

A NEW PLANS HANDBOOK

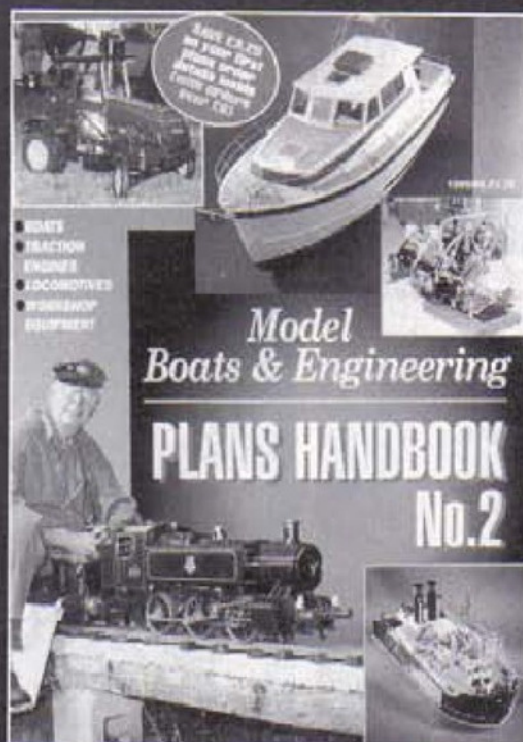
The 1995/1996 Edition of our Plans Handbook No.2 has just been published.

This Handbook, which covers the Model Boats and Model Engineering sections of the Plans Service, will be of particular interest to readers of MEW because it is the one which lists the Workshop Equipment drawings.

Accumulated over many years, the range includes designs from contributors whose names are often quoted in this magazine. Prominent among them are George Thomas, Dave Lammas, Martin Cleeve, Edgar Westbury and the 'Duplex' team of Dr. Norman Hallows and Ian Bradley.

Most of the designs were featured in *Model Engineer*, but others come from the old *Model Maker* and *Model Mechanic* titles.

The price this year is £3.25 plus 85p post and packing, with the cover price being refundable with the first purchase of a value over £6.00 ordered from the new handbook. Available from: Plans Service, Nexus House, Boundary Way, Hemel Hempstead, HP2 7ST.



A SLOTTING DEVICE FOR THE MYFORD S7 LATHE

Pat Twist provides a design for a simple to make slotting attachment for a Series Seven lathe.

I needed to make the part shown in **photo 1**, but the results of trying to do it with files were unsatisfactory, square internal corners were required and a straight rectangular hole that was not barrel shaped in the middle.

After some thought a slotting attachment was indicated, preferably to fit on the Myford lathe bed to be driven via the 4 jaw chuck, (the 4 jaw to enable me to vary the stroke of the slotting tool). The final design of the resulting device is shown in the Assembly drawing and **photo 2**.

The cost of having the basic part of the device, Item 1, welded up from plate with side webs was too high, so a pattern (**photo 3**) was made and a casting procured.

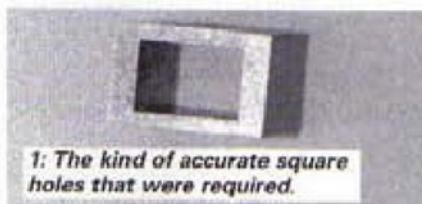
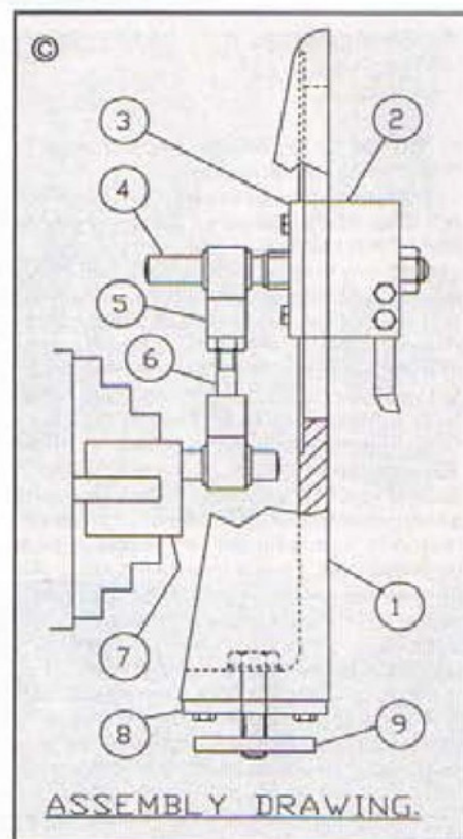
Normally I like to swab castings with spirits of salts (hydrochloric acid) and leave them out in the open for as long as possible for a thick layer of rust to form. This gets rid of grains of casting sand and to some extent the hard skin on the casting.

I was not prepared to wait that long, so the part was rough machined and left for a fortnight to relax, and re-machined again to final dimensions. It is of interest to note that in that time, the strains locked up in the casting had relaxed to the extent that the piece had bowed by 0.5 mm. Checking again on the surface plate some months later, after final machining it was noticed that it had relaxed a little more, but only by about 0.05 mm. The following notes are provided for anyone wishing to produce a

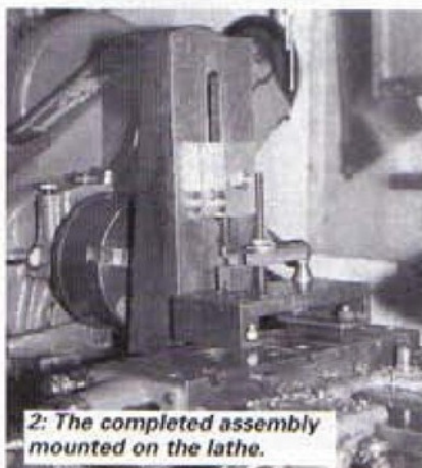
similar unit, as arrangements have been made for castings for the main support angle, Item 1, to be made from the original pattern.

Any high spots on the long face should be removed with an old file, so that the casting will lie flat, without rocking. The two 10.5 mm dia holes are drilled 50 mm apart, for bolting the casting to the lathe cross slide for flycutting the bottom face. The casting needs to be supported on parallels with the long face of the casting 19 mm above the cross slide (**photo 4**). This allows the 10.5 mm dia hole to be drilled without moving the set-up other than changing the flycutter for a centre drill and drill. That hole now needs to be spot faced on the rough casting side for the locking nut and washer. If spot facing tool is unavailable, the cutter from a tap re-seating tool screwed onto a short length of rod held in the chuck would do, but with such a small amount of metal to remove, do not risk the chuck unscrewing by running the lathe in reverse, use the chuck key as a lever in the chuck. This small job can be done by hand. With the base machined, the casting can now be transferred to the milling machine. Bolt an angle plate to the table of the mill with the casting bolted to the angle plate, long flat side uppermost. Support the other end of the casting on packing and clamp down to the table, see **photo 5**. The long face of the casting can now be machined, an excellent tool for this is the four cutter facing tool, supplied with most of the popular bench milling machines.

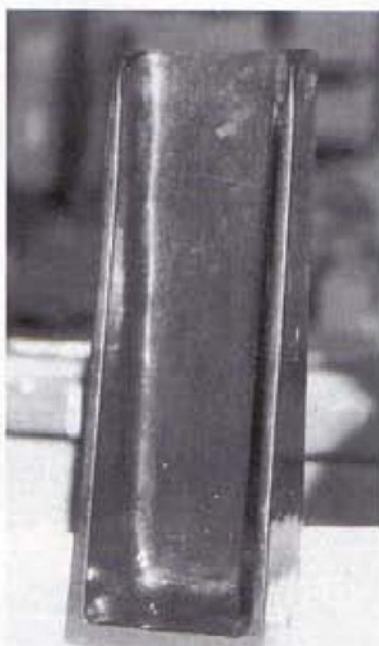
The small area under the clamp at the end can be finished off with a file later. A 12 mm slot drill may now be used to cut



1: The kind of accurate square holes that were required.



2: The completed assembly mounted on the lathe.



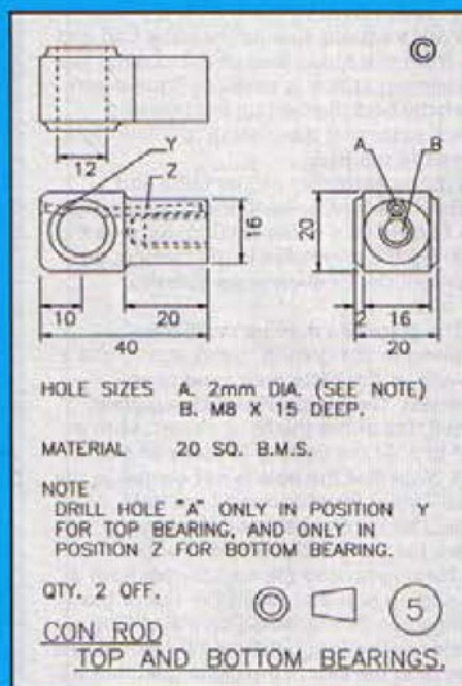
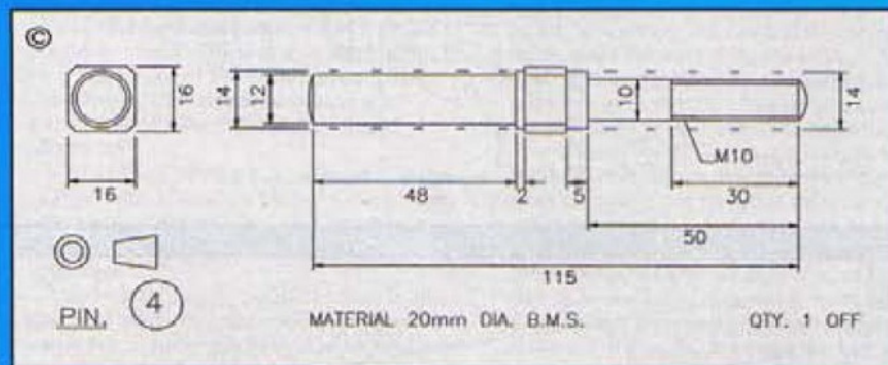
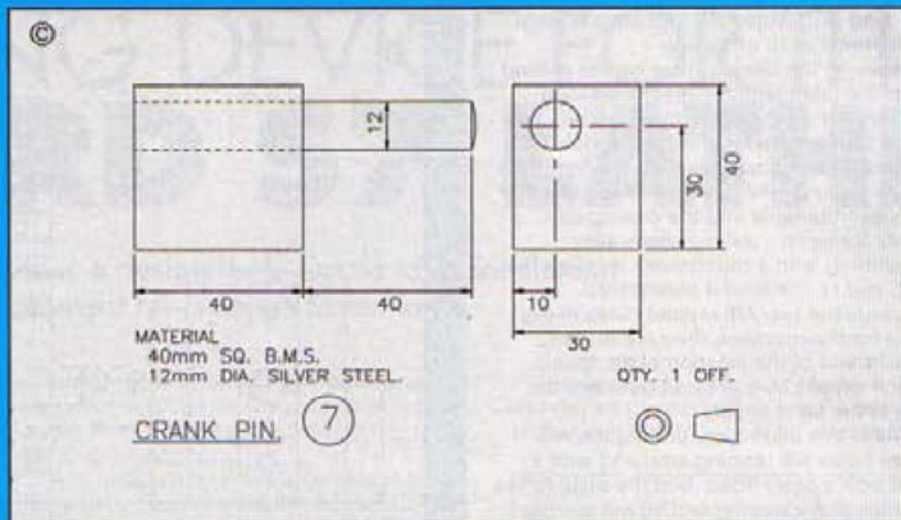
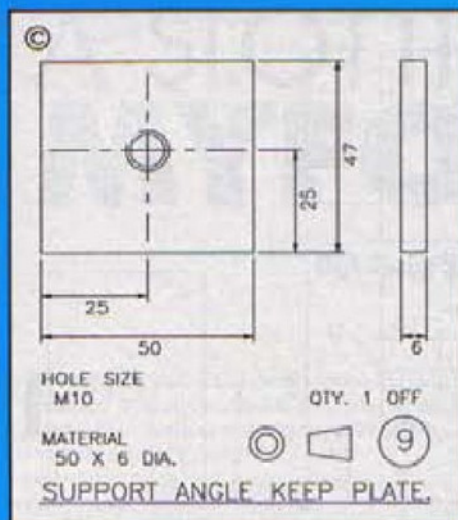
3: Pattern for the C.I. casting.



4: Fly cutting the base.



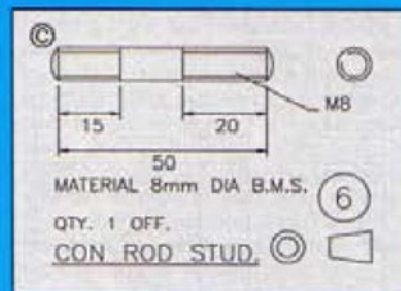
5: Milling the long face and cutting the slot.



Casting availability

Castings for the main Support Angle, Item 1, are available from The College Engineering Supply, 2 Sandy Lane, Codsall, Wolverhampton. WV8 1EJ.

Tel. or Fax: 01902 842284



the cutter is best finished with a flat bottom to take the thrust of the cutter. Two M5 screws will hold it in place.

The pin for the tool carrier can be made from a length of 20 mm dia MS. Face and centre each end and between centres, turn the 48 mm length to 12 mm dia. plus 2 mm at 14 mm dia. Turn end for end between centres (protecting the 12 mm dia in the lathe carrier with a short length of copper tube) and turn the remainder to 10 mm and 14 mm dia then screwcut M10 x 30 mm long.

The spanner flats could be filed, but are more easily done on the mill, holding the bar horizontally in the m/c vice with each end supported on packing, the vice jaws gripping the largest diameter near the top of the vice, Traverse the vice under a cutter at right angles to the bar for a small cut, turn the bar in the vice 90 deg. for another cut, ditto, and ditto again, ending up with four flats all equal in size.

The bar can now be entered into the tool carrier and screwed home with a spanner.

Make the tool carrier keep plate, Item 3, next. Bore the hole which should just pass

over the squared spanner flats mentioned above, clamp in place against the tool carrier, and drill two M5 tapping holes through the plate and into the carrier, taking care to avoid breaking into the previously drilled oil passages in the tongue. Tap the holes M5 in the carrier and open out the two holes in the plate to 5.2 mm dia. Mark the plate so that it goes back the same way round when re-assembled.

A small length of 40 mm sq. MS was used with a length of 12 mm dia silver steel for the crank pin, Item 7. Held in the four jaw chuck, the throw can be adjusted to suit the work to be slotted.

The con-rod, Items 5 & 6, is adjustable in length and the assembly was made from scraps available, as can be seen in photos 6 and 7. However, the drawings show a more ordered approach, with both ends being identical other than the position of the oil holes.

While the tool will make nice clean cut square corners, it is advisable to remove all surplus metal first by drilling and/or milling, using the slotter to finish off the work.



6: Crank pin held in 4 jaw chuck

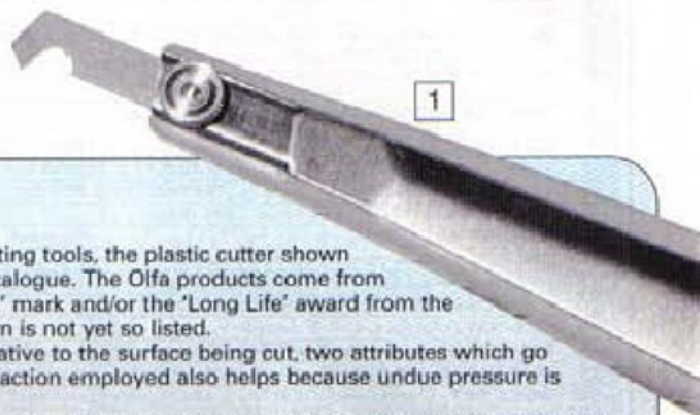
7: Rear view of completed slotter.



PRODUCT REVIEWS

This brief look at some items from the trade focuses on some smaller tooling of interest

The Olfa Plastic Cutter/P450



Shesto Ltd have recently begun to stock the Olfa range of knives and cutting tools, the plastic cutter shown in **Photo 1** being one of those listed in the extensive and well illustrated catalogue. The Olfa products come from Japan, where a number of items in the range have gained the 'Good Design' mark and/or the 'Long Life' award from the Ministry of International Trade and Industry (MITI), although the cutter shown is not yet so listed.

When trying the P450, it felt comfortable in the hand and controllable relative to the surface being cut, two attributes which go a long way to ensuring safe handling. With this particular cutter, the cutting action employed also helps because undue pressure is not needed to make an impression on the material.

This cutting action is more a machining process, with a definite kerf, as opposed to the parting action employed by the conventional craft knife. The instructions on the carton recommend that the more brittle materials, such as Formica should be scored part way through, then snapped off. This is not possible with the more malleable plastics, but with a succession of cuts, these could be parted cleanly. It was advantageous to make two or three cuts on the underside before cutting all the way through, in order to prevent the blade snagging in the surface on which the material was placed (in this case, a piece of melamine faced chipboard). When cutting, it was found best to keep the 'angle of attack' of the tungsten carbide blade low, and to draw it through the material.

Styrene sheet 0.028in. thick was parted in three or four passes, while a thicker plastic of about 0.125in. took fifteen or so, but the edge which remained was much cleaner than would be achieved by sawing.

This cutter was very effective and also proved to be the ideal tool for undercutting the insulation between the bars of the cleaned-up commutator of a starter motor. If typical of the performance of all the Olfa products this interesting range can be recommended.

Supplier: Shesto Ltd, Unit 2 Sapcote Trading Centre, 374 High Road, Willesden, London, NW10 2DH Tel. 0181 451 6188 Fax. 0181 451 5450.

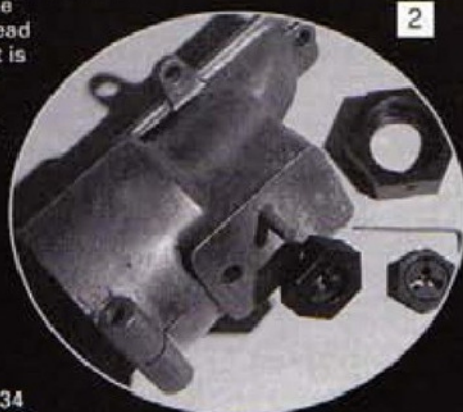
Die Holders from Tracy Tools

Tracy Tools have introduced a set of die holders which turn conventional split dies into the equivalent of die nuts (**Photo 2**), so simple yet very effective. When cleaning up a thread, particularly in the restoration activity, it is often not possible to use the conventional die stock because of clearance considerations, so the die nut, rotated by a socket spanner is often the only option. The drawback is that these are not cheap, being quoted at twice the price of the equivalent split die, so if one's tool kit already holds the dies, it can be frustrating.

Although die nuts are specifically formed for cleaning up threads as opposed to forming a new one, the split die will do the job just as well (keep the ones retired from 'front line duty' for this purpose). Tracy's simple adapters are therefore just what is needed.

The three sizes are intended for $\frac{13}{16}$ in., 1in. and $1\frac{1}{2}$ in. dies and fit $1\frac{1}{16}$ in., $1\frac{1}{4}$ in. and 2in. A/F spanners respectively. The dies are secured by a pair of diametrically opposed socket head grub screws, so some measure of thread size adjustment is possible. They are a useful addition to the renovator's toolkit.

Supplier:
Tracy Tools
Ltd., 2
Mayors
Avenue,
Dartmouth,
South Devon.
TQ6 9NC
Tel. 01803 833134
Fax. 01803 834588



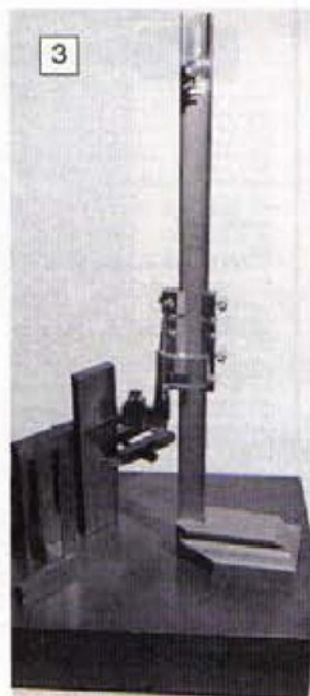
A Vernier Height Gauge from Chester U.K.

This 30cm/12in. height gauge (**Photo 3**) has a nice look and feel to it. Removed from its packing and with protective grease cleaned from the threads, it moved smoothly across a lightly oiled surface plate and felt stable. The scales appear to be satin chrome and the non-working parts are protected by a grey enamel.

The main scale has an adjustable datum over a range of about 40mm, with both coarse and fine movements. The graduations were clear and easy to read, as were those on the sliding vernier scale, but help is also available should it be needed, in the shape of a clip-on magnifier. In the absence of Standards Room quality equipment, no assessment of accuracy could be undertaken, but comparing some sample measurements with those made using a known 24in. Brown & Sharpe gauge, the variations noted were within the sort of range one would expect from this type of instrument. The chisel point is equipped with a tungsten carbide insert and gave a good sharp scribed line on mild steel.

The unit is supplied in a well fitted wooden case, which was slightly let down by the quality of the hinges and clasps, but in all this was felt to be an instrument in which one could have confidence. Although the vernier is now being superseded by the digital read-out, the cost of such devices is still high and the traditional type can still do the job.

Supplier: Chester U.K. Ltd., Waverton Business Park, Waverton, Chester. CH3 7PD Tel. 01244 336100 Fax. 01244 336036



From the new Chronos catalogue

Chronos Limited have recently released Issue No.29 of their remarkably comprehensive 92 page catalogue. We have had the opportunity of examining five items from their range. The first is a small plastic handle (Photo 4) for Swiss files, rifflers and similar small tools. The fluted handle is triangular in section and is fitted with a brass collet assembly which is closed by a knurled screwed ferrule. The maximum capacity is of the order of 3.2mm diameter

Photo 5 shows a useful accessory which overcomes the problem of how to achieve the rigid mounting of a Dial Test Indicator on a milling machine or drill which has a circular column, with a maximum diameter of 50mm. The adjustable arms are clamped using knurled nuts and the clock gauge fitting can be either the conventional dovetail or a pin of 4mm diameter which will pass through a cross drilling in the shaft of the end clamp.

The 0 - 25mm electronic digital micrometer shown in Photo 6 is a dual system instrument, switching from imperial to metric at the touch of one of the buttons on the frame. The other button operates the zero reset which can be activated at any point in the range to provide a comparator facility. The anvils are fitted with carbide tips and the usual ratchet and clamp are provided. The electronics feature what the simple operating instruction leaflet lists as 'auto switch off'. This leaflet contains one or two of the familiar gems of the translators art, but is quite understandable.

The remaining items are both lathe tools, which were tried out on Stan Bray's small Toyo lathe. Photo 7 shows a small parting tool with an inserted blade. The body is only 5/16in. square and the 2 1/2in. long blade is 1/4 in. wide and 1/16in. thick, so it is intended for the range of work which can be carried out on the smaller lathes. The final item from Chronos is the Small Diameter Turning Tool designed by Allan Mackintosh and made by Jabus Engineering of North Devon. (Photo 8) It is essentially a toolholder for a right hand knife tool with an integral bushing steady. The bushes are consumable bronze or brass slugs of 5/8 in. diameter which are clamped in

a housing, immediately adjacent to the cutting edge of the tool by two 4BA socket head screws. The 1/4 in. square HSS cutting tool is controlled within the holder by an adjusting screw with which the depth of cut is set. In operation, the centre of the bush (and, of course, the cutting tool) is set on centre height and the bush drilled from the headstock at the diameter of the stock material to be reduced (hexagon can be handled as well as round). With the stock in the chuck and supported by the bush (and the cross slide locked!), the tool bit is set to give the required depth of cut and the stock reduced in one pass. As

suggested by the instruction leaflet, careful grinding and honing of the tool to the optimum angles for the material and the diameters being handled pays dividends. Manufacture of long bolts in BA sizes is one of the tasks for which this tool is suited.

Supplier: Chronos Ltd., 95 Victoria Street, St.Albans, Herts. AL1 3TJ. Tel. 01727 832793 Fax 01727 848130

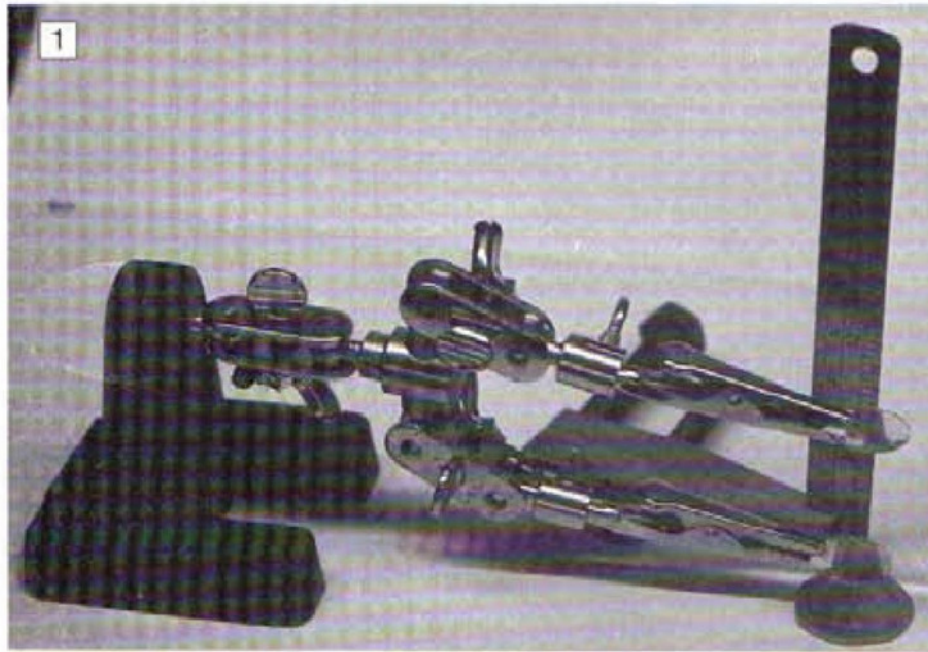


Castell Engineering Supplies

Castell Engineering Supplies is a long established company that understands the requirements of the users of the home workshop, particularly the need for those good quality hand tools which are so essential to producing high quality work in the traditional way. They have recently estimated that they have in stock over 500 different sizes and types of files as well as all the other tools such as squares, scribers, hacksaws which form the basis of the tool kit of both the novice and the skilled engineering craftsman. A copy of their catalogue is well worth keeping on the bookshelf.

Supplier: Castell Engineering Supplies Company, Western Gardens, Ealing, London W5 3RS. Tel. 0181 992 5682/3 Fax 0181 992 0466.

CO-ORDINATE MEASURING



1: Set-up for determining spacing of lenses.



Expensive co-ordinate measuring machines, are not a machine for the home workshop. J. Freed offers an economic solution, having adequate accuracy for the majority of applications.

We all know the lathe can be used for more than just turning. One possibility is as a co-ordinate measuring device. To this end, a low power microscope plus a source of illumination will be useful. "Microscope" is a grand term for what is little more than a simple magnifier, but the former is the term generally used, so we will stick to that.

The cost need not deter anyone, as the whole thing was made from surplus materials for about £1, not including the 12 volt power pack, as readers may prefer to use batteries instead.

The problem which gave rise to the need for this device, was the measuring of clock lantern pinions. No doubt ordinary pinions, even small ones below 0.2 in. (5 mm.) diameter, could be measured by making a few attachments for an ordinary micrometer. However, when it comes to a lantern pinion, that is not easy, especially if badly worn and one needs to measure the pitch circle diameter of the pins or holes. Accordingly the following solution was evolved. Much larger components can also be measured, and "x-y" co-ordinates plotted too.

Most leadscrews are fitted with an indexing dial, enabling the carriage to be advanced through distances accurate to 0.001 in. (0.0254 mm.). The accuracy of even a fairly poor commercial leadscrew is better than 0.002 in. in 6 in., and for a precision cut one it is 0.0001 in. in 6 in. (ref. *Workshop Technology*, part 2 by W.A.J. Chapman, published by Edward Arnold 1959.). It is reasonable therefore, to

assume the average lathe weighs in at better than 0.001 in. in 6 inches.

Digressing, but still on the subject of leadscrews, there was an excellent article by Don Unwin in an earlier issue, from which there arises the comforting thought that pitch errors are largely self-correcting. In other words, over the years, lathes have gone on becoming more and more accurate without any help from us. In fact lathes used for ruling diffraction gratings have a leadscrew driving a nut which has no thread at all. A very soft split nut is clamped onto the screw, which forms its own thread as the leadscrew rotates, ensuring the ultimate match.

Manufacture

The equipment consists of two basic items, the microscope, and the illuminator. Very few dimensions are given as the details are heavily dependent on the optical components which are to hand, or can be obtained. There is nothing very critical with regard to the lenses, those used by the author were obtained from J.A.Crew.

The focal length of each lens can be checked by the "distant object method". Hold up the lens and a piece of card over a steel rule, and focus on a distant tree or such. There are plenty of suitable lenses available, and they are not expensive. If you cannot locate any on the surplus market, try your optician or photographic dealer. Selection can be made by trial and error, or if you want to be a little more

scientific, consult a physics text book to relate focal length to image and object distances. In the case of laboratory instruments the focal length of objectives is very short (0.08 to 0.5 in.), but we do not need such high magnification. In the case of those used here the focal length of each lens was about 2 in., and of the combination, about 1 in. The magnification was about x4. Using hindsight, the object lens would probably have been better with a somewhat shorter focal length, and the eyepiece a slightly longer one.

It is worth mentioning that a microscope, either a laboratory instrument, or our simple one, is focused by moving it as a whole: the eyepiece and the objective do not move relative to each other. When you have a promising combination, set the lenses up temporarily in clamps such as the popular Helping Hands, see photo 1. Small pieces of masking tape will prevent them from "orange pipping" out. The writer made a shorter cross bar for the Helping Hands as it is often convenient to get the two clamps closer than is possible with the four inch crossbar supplied, it was made from 5/16 in. dia. brass bar. A rub over with silver plating solution, which is widely available now, and it matches the rest of the kit quite well. To check the suitability of the lenses, focus on a small coin or a steel rule.

At this stage it is convenient to experiment with the index mark or "cross hair". Suitable materials are polycarbonate, acrylic, or acetate sheet, about 0.03 in. (0.8 mm.) thick. Cut a piece the diameter of the

viewing tube, polish it, and scribe a line across it using a scalpel or a sharp knife. A normal scriber makes a rather coarse line. Two lines at right angles are required if one intends to make coordinate measurements. Fill the line with white or black paint or ink, wiping the surface clean. You may find that white shows up better than black, in fact the author used typist's correcting fluid. A number of trials may be needed, so make a few pieces.

Stand a steel rule alongside the set-up as shown and note the measurements. This will provide the basic dimensions.

The microscope

The main body was made of steel; only because a suitable size of steel tube was to hand, better material would be brass or aluminium alloy. Each end was bored to clear the lenses, and the plastic retainers were machined to be a push fit in the tube. Alternatively, use a microscope thread, but it is much easier to experiment if plain bores are used. The whole assembly can be bonded together later, if necessary, using one of the proprietary adhesives.

The retainer for the object lens is cut back on one side to allow more light onto the workpiece, because the assembly is very close to the work when in use. It is also bored for the disc marked with the "cross hair" or index mark, so, when cutting it back, leave more than a semi-circle to provide a better grip. The form of the eyepiece can be seen in fig. 1. This can also be a push fit in the tube to retain the eyepiece lens, and bonded in later if necessary. There are many suitable plastics for the eyepiece and retainer, e.g. phenolic laminate, or even old-fashioned vulcanite type plastics.

The illuminator

The main requirement is to get the bulb as close to the object as possible, say about 0.03in. clear, and aim to have the filament about level with the end of the tube, see fig 2, and photo 2. The bulb was a 12 volt 2 watt MES bulb but there is nothing critical about the rating. It just needs to be reasonably bright. The socket was taken from a discarded torch, and lugs were bolted to the centre contact with an insulated bush for the outer one. A piece of plastic rod was bored out to take the socket making it a push fit, and the outside diameter was machined to be a push fit in the casing. A bush was turned to accept the cable, and made a tight fit in the casing. That is all there is, except for a few items of bracketry.

Brackets

Here again this is quite straightforward. If you have a vertical slide, so much the better as this greatly assists in focussing. Focussing is achieved by moving the whole assembly up and down, so you need to mount the vertical slide, or a suitable angle bracket on the cross slide. Onto this goes a mounting plate for the microscope and illuminator. A suggested plate is

shown in fig 3. The only hole which needs to be slotted is the one for the illuminator to achieve the optimum position for it. The remaining hardware consists of clips, bolts, and spacer tubes.

Uses

i) **Setting Up.** After bolting the bracket to the vertical slide, bolt on the microscope and the illuminator, and try it with power on. Clamp a piece of flat to the lathe bed and bolt a piece of angle onto it, about 8 in. long. Clamp a finely divided good quality rule onto the angle, and adjust the cross and vertical slides until it comes into focus. Traverse back to one of the major marks on the rule, and note the reading of the leadscrew feed dial. Traverse, say five inches, and again note the dial reading. They should agree very closely. This

constitutes not so much a calibration of the instrument, but rather a demonstration of the accuracy of your leadscrew. **Photo 3** shows this set up, and that on the contents page, the same set-up in close-up.

ii) **Measuring a profile.** **Photo 4** shows a small pinion being measured. This is held on the platform by double backed tape, and readings taken from the leadscrew and cross slide scales. To give an indication of scale, the outside diameter is 0.15in.. You can probably visualise from this what a help it is in making "fiddley" measurements, especially if the shape is complex. The lack of contrast in the photograph is due to the low light level and extra magnification by the camera. These are not a problem when viewing directly by eye. Only a small number of co-ordinates have been shown in order not to confuse the picture, in practice the number would be increased. How one uses the data, e.g. to profile a suitable cutting tool is a whole separate subject, and would require an

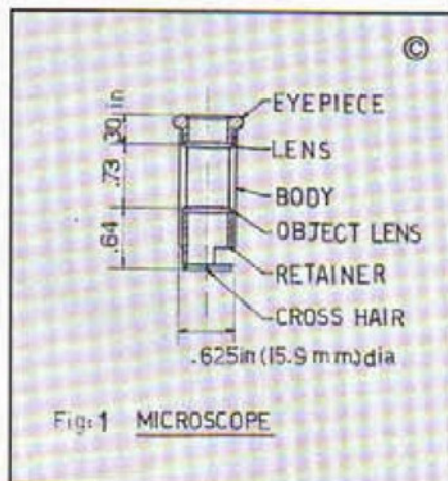


Fig. 1 MICROSCOPE

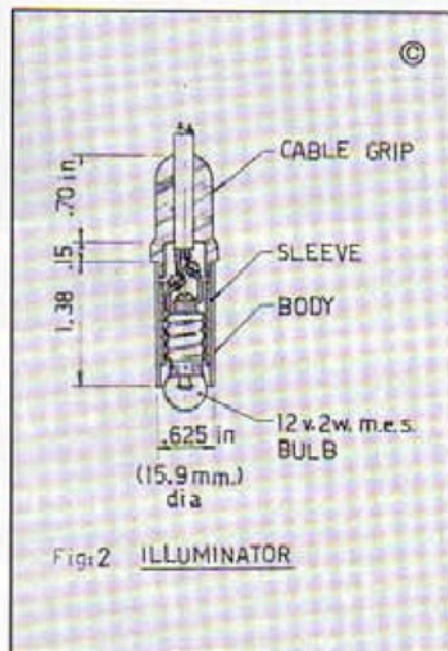
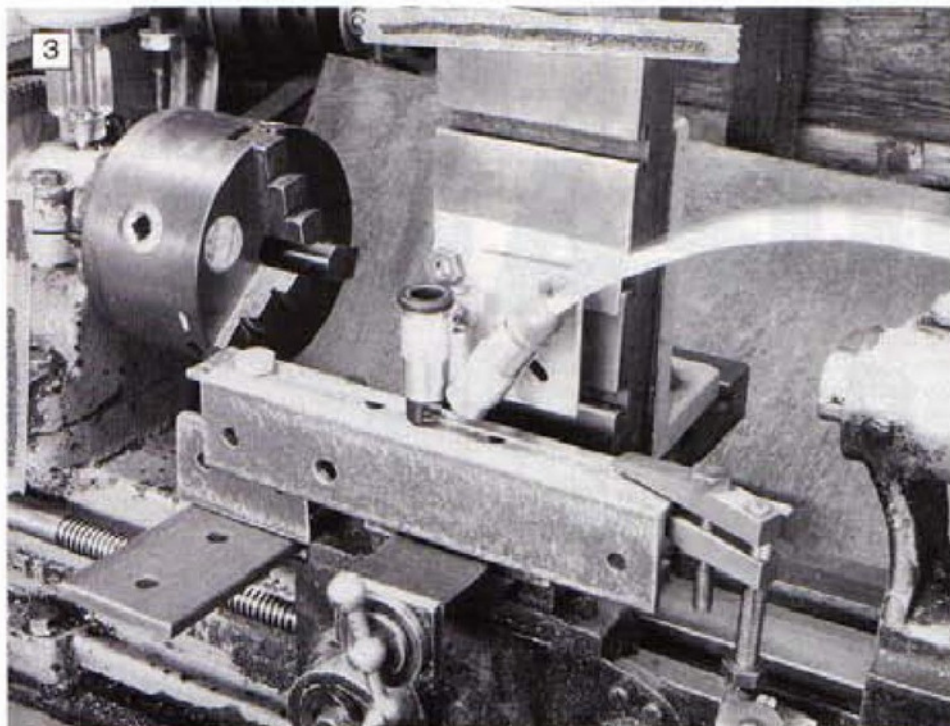


Fig. 2 ILLUMINATOR



2: Close-up of the finished article.



3: The unit in use, comparing lead screw pitch with calibrations on a ruler. See also photo on contents page.

input from a toolmaker.

iii) **Use as a micrometer.** This is a straightforward application and only involves the making of two small buttons about $\frac{1}{2}$ in. diameter, one gripped in the chuck, the other clamped in the toolpost. These serve as the anvil and thimble of a "micrometer". Traverse the toolpost button up to the button in the chuck until they just touch, and note the lead screw reading. Wind the tool post back to accommodate whatever it is you wish to measure. Close the tool post button onto the component very gently, as it can exert quite a force, and again note the lead screw reading. This will give you the length of the component to a "thou". You now have a very big micrometer. Measuring overall lengths does not require the use of the microscope, but if you have an item with several features to measure, such as shoulders, recesses, and so forth, set up the item, in the chuck or between centres, as best suits the part.

Then, with the microscope mounted on the vertical slide, it can be traversed and readings noted for each feature.

iv) **Coordinate measurements.** It will be found that the methods described so far can be extended to enable the lathe to be used as a jig borer for clock plates, or loco frames etc., provided they can be accommodated on the lathe bed. There are, of course, several ways to proceed. Firstly, it may be convenient to remove the chuck and the tailstock to allow more room. Next clamp a piece of planed hardwood to the lathe bed close to the headstock. The component can be marked out, but without centre punching, except for one reference hole. The microscope can then be mounted on the vertical slide, and used to check the marking out by noting the lead screw and cross-slide readings. Next replace the

4: Measuring a pinion profile, pinion diameter 0.15in.

microscope by a drilling spindle and drill the holes on the measured co-ordinates.

This device will not revolutionise your workshop, but it will be found to have many uses, not only on the lathe, but also on other machines such as the vertical mill. Hopefully it will also tempt you to explore the use of other optical equipment.

A caution

It should be remembered that not all lathes are fitted with lead screws which will conveniently divide in 0.001in. Readers using older machines, such as the Zyto, Winfield etc. should check on their machines for suitability before embarking on this exercise.



Supplier mentioned

J A Crew and Co, Watery Gate Farm, Dovers Hill, Chipping Campden, Gloucestershire, GL55 6OU. Tel 01386 841979. New catalogue, number 28 is now available price £ 1.00.

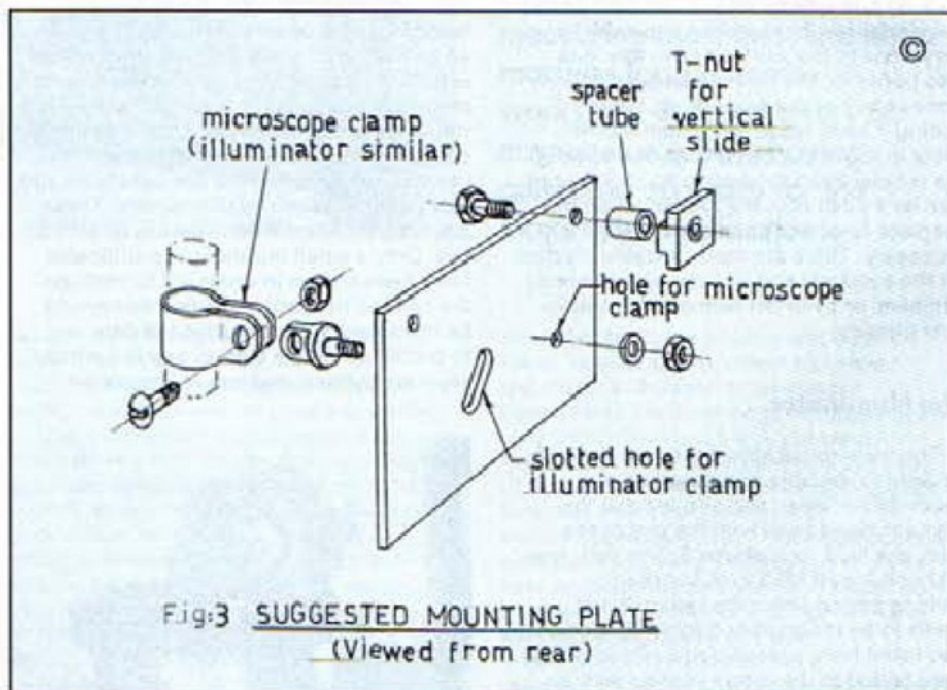
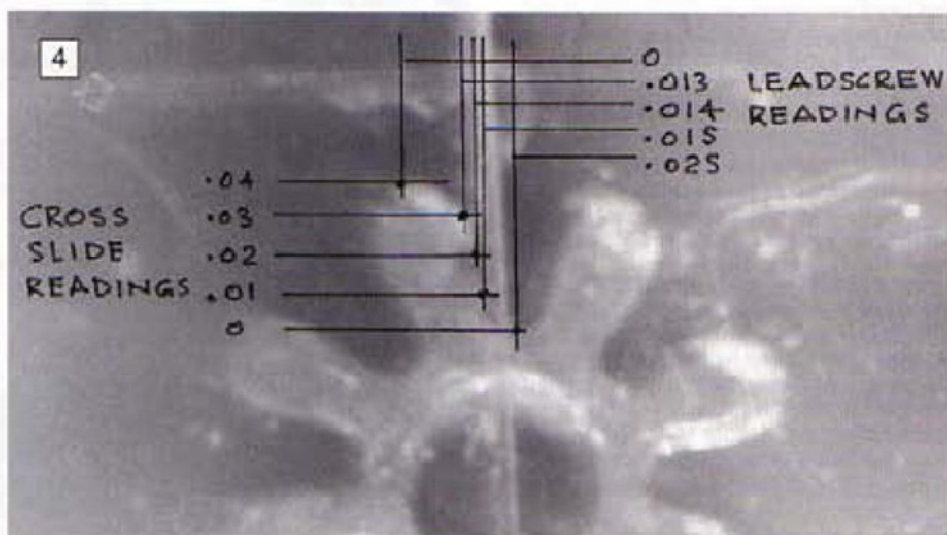
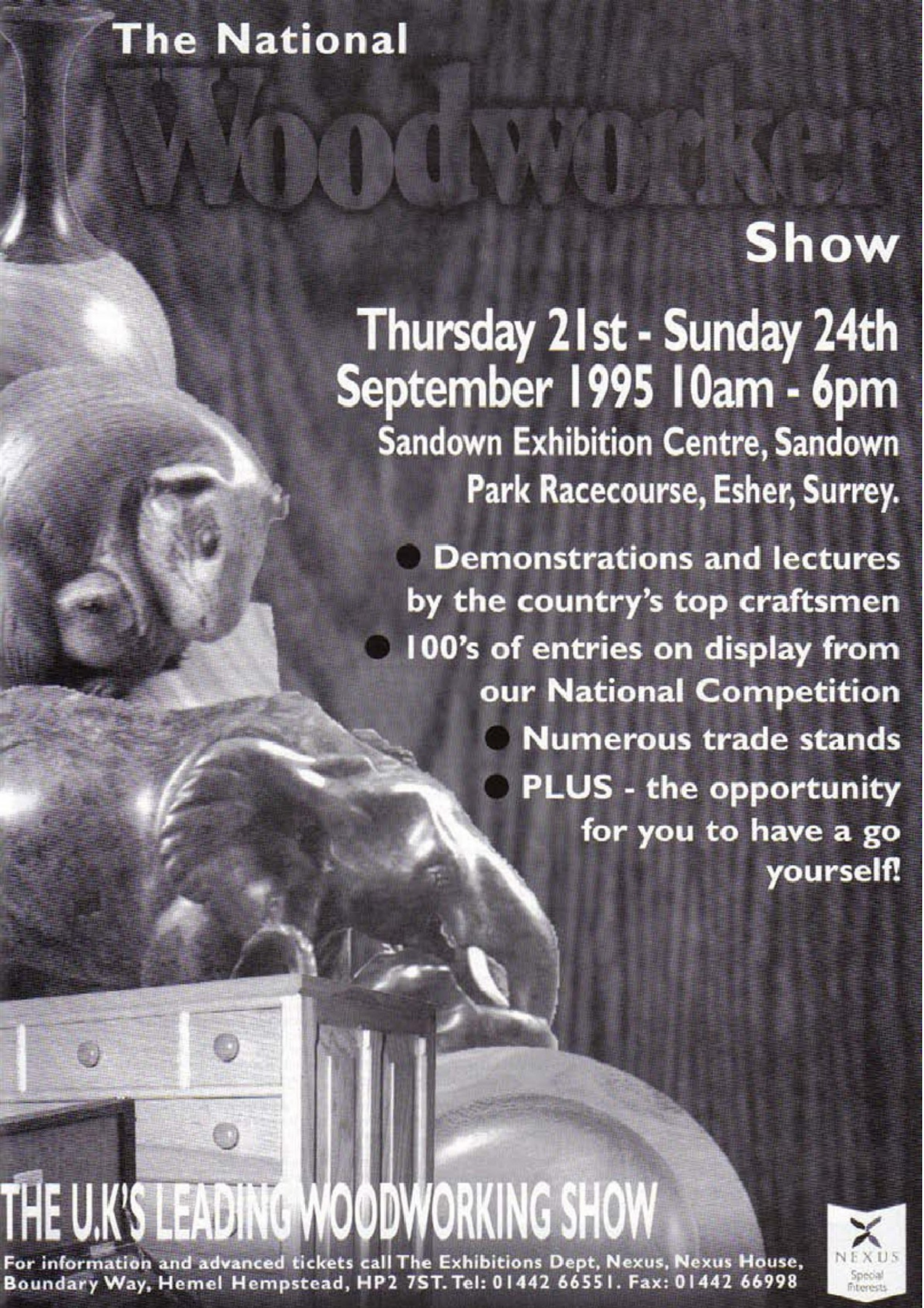


Fig:3 SUGGESTED MOUNTING PLATE (Viewed from rear)





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SCRIBE A LINE

Side Grinding (MEW 28 Page 12)

From D. K Jerrard, Exeter, Devon

Side grinding has always been a problem and as a general principle is to be discouraged because of the danger of undercutting the stone and thus weakening its structure. When I was an apprentice in the machine shop, over 50 years ago, we had several grinders on the shop floor for tool grinding only. We were shown how to sharpen lathe tools and drills. With lathe tools, one used both the face and the sides of the wheel. Drills were ground using the face only. These wheels were kept dressed and in good condition. If anyone was seen using them for other purposes then they were liable to be sacked. If used sensibly for tools only, no problem arose. The trouble was that they got used by all and sundry for grinding off bits of metal. Often the side face was used to round off the end of a rod and this grooves the side of the wheel, so the rule is Tools only on the grinder and sensible side grinding.

Your contributor makes reference to commercial drill grinding attachments, which use the side of the wheel. It is the misuse of these that has caused many of the problems. Suppose I were to grind, say, a broken 3/8in. drill. I put it in the attachment and then grind away; now quite a lot of metal has to be removed to reshape the drill, which usually breaks with a tongue of metal proud of the rest of the drill. This acts as a sharp gouge and will soon groove a good stone. The proper way to do the job is to free hand grind to approximate shape on the face of the stone, then finish on the attachment.

I have a copy of Grinding Wheel Regulations somewhere, but I cannot put my hand on them at this moment. I think they suggest that side grinding is not carried out, but do not specifically ban it - if they did it would be ignored!

X - Y Table Query

A number of correspondents have queried a feature of Ray Stuart's x - y table design. Their points can probably be best summarised by an extract from a letter from Mr. M.A. Thorpe of Old Arley, North Warwickshire, in which he states:-

"I am a little mystified by where the control line for the pen up and down signal comes from, as all 8 output lines are used."

Ray Stuart's response is as follows:-

The system was designed to work with 2D-CAD packages which are designed to work with conventional pen plotters where the pen is either up or down using

the HPGL commands, PU and PD, to raise and lower the pen.

When I designed the system I had in mind using it, among others, with a pillar drill for co-ordinate drilling where the up and down movement of the drill would be manual as the CAD packages could not specify depth. Hence the software displays a message as to whether the 'pen', or tool as it now is, should be up or down. Giving that readers will have different ideas, applications and methods of moving their particular tool, the option of indicating the tool position, (up or down), was selected. The tool position is displayed on the screen and confirmation that the tool is in the desired position is requested before the table can be moved.

Consequently there are no signals provided to automatically raise or lower the tool.

A source of 'treasure'

From Chris Grogan, Albury, New South Wales.

Reading Ray Stuart's articles on motors, and in particular stepper motors, prompts me to make your readers aware of a plentiful supply of stepper motors 'for free'. (With apologies to Electromail!)

Not only will this free supply furnish stepper motors, but other wonderful bits and pieces for the model engineer are to be found. Bits such as geared motors, bearings, relays, solenoids, precision ground shafts, chains, sprockets, gears and transformers for power supplies.

The Alladins Cave I refer to is your local photocopier service centre! Every year, thousands of copiers become unloved and unwanted and are traded in. They usually then spend some time in copier purgatory minus a few recycled parts until the go to the great office in the sky.

Why not save these poor lost souls from this fate and speak to your local dealer. Most will be happy to give you a machine or three - it saves them the time and cost of storing and then dumping them.

The larger, older machines have more useful mechanical bits, but the smaller machines will still yield a remarkable amount of useful parts.

Happy hunting!

David Wilkinson's Radio Interference problem — Readers respond

From Gordon Read Waltham Chase, Southampton.

Dave Wilkinson's radio interference problem (MEW No. 29), raises memories of RFI-chasing during a working lifetime in various aspects of electronics. Curing

RFI is never easy!

There are laws that say equipment sold must not generate RFI, but the reality is that some things do generate it. Radio Frequency Interference (RFI) can be transmitted in three ways, or any combination of the three. First, it can be directly radiated by the generating equipment acting like a radio transmitter. Second, it can be propagated along the mains leads from the equipment, and so into the nearby mains system. Third, it can produce magnetic fields of the interference near the mains or other connecting cables. The first task is always to discover which is occurring: never easy!

Most converters of the type referred to incorporate oscillators which often produce square waves. These have harmonic content at radio frequencies, just as do the pulses from car ignition coils. Those harmonics have to be stopped from getting where they can cause interference.

Direct radiation requires the equipment to be in screened and earthed covers. The problem with that is ensuring that all the covering metal is really at earth potential. Large covers and screened cables can sometimes have significant interference current in them, so acting as aerials.

Mains propagation is dealt with by inserting a filter in the supply lead, right close up to the source. Such filters consist of series inductance and parallel capacitance, producing high series impedance and low parallel impedance to the RFI: this works on the assumption that the RFI is of low impedance, which is sometimes not the case.

Induction pickup from near mains leads will be stopped by a filter in the mains, because it cannot occur unless there are RFI currents in the mains cables.

The fact of the matter is that if the circuit design of a piece of equipment is such as to inevitably be an RFI source, it should be designed in the first place with RFI prevention internally. This being so, the actual converter should not, by law, be itself a source of RFI.

If Mr. Wilkinson cares to contact me through the Editor, I can give him instructions on how to make a mains RFI filter which will not cost much; a few pounds at most, and the making of it will be well within the capabilities of any model engineer. Trying that would be a reasonable first step.

And from K.A. Willson, Fleet, Hampshire.

David Wilkinson, London (MEW 29), seeks help and assistance regarding interference from his ABB ACS 200/3 phase motor combination and long wave radio.

The switching frequency of the ACS 200 lies between 1.0 and 16.0 kHz (page 2 parameters). In view of the power involved it is possible that a high harmonic is being generated which would be right in the middle of the long wave band.

Re-adjusting the switching rate may at least move it away from the station frequency, but a filter would be far more likely to help. Unfortunately merely screening the cables does not, as David Wilkinson found, help if the cables themselves are not dealt with.

Filter blocks are available which prevent such mains borne interference reaching sensitive equipment (RS 239-680 & RS 210-412, around £5 - £10). In this case the trick would be to place such a filter between the ACS 200 and the incoming mains, but, connect the filter block INPUT to the INPUT of the ACS 200, this should severely attenuate the cable borne signal. At the same time the screening should be firmly grounded both to the filter case earth and the mains earth.

Good luck.

Accurate Division With Simple Tools.

From D.C.K.Pearce (Joint Librarian, Society of Ornamental Turners)
'Hurgada' 170 Green Lane, Shepperton, Middlesex. TW17 8DZ.

Referring to MEW No. 28 page 21, Mr. H.S. Harvey is to be complimented on his interesting article bringing to the notice of model engineers the possibilities of indexing by using two opposing rows of balls in contact. Also Harold Hall's suggestion to use a single row of balls with some form of detent pin sounds quite novel.

I have to say in support of friends and colleagues that both these methods have been known to precision engineers for some years. I was fortunate in being concerned with the measuring, as far as I know, of the first indexing device using two opposing rows of captive balls. This idea was patented by Messrs Jennings, Robinson, Atkins and Partridge (Patent No. 1,044,355 September 1966). This patent also suggested using two of these units in tandem, to remove the need for extremely large PCDs for the rows of balls. For example 360 balls would be required in each row if one wished to index every degree, and with balls say 1/4in. dia., one would need a 28 1/2in. dia. row of balls. By using two units in tandem, one having two rows of 40 balls and the other two rows of 36 balls, the minimum indexing intervals are 9deg. and 10deg. respectively but by indexing the first unit negatively and then the second unit positively the net result is a change of one degree. The ball indexing idea was applied to a device for calibrating the angular rotation of various engineering instruments and it could provide a very searching test if one chose for example 52 balls (6deg. 55min. 23.08sec. interval) as the degree, minute

and seconds scales had to be read.

The ball indexing idea was taken up by the Japanese and used in rotary tables and dividing heads. I believe it was a German company, Servopress-Maschinenbau, who improved the ball idea in their Servo-Dex rotary tables by having the upper row of balls slightly larger in diameter than the lower row of balls thus ensuring a positive self centring effect.

Prior to the idea of the double row of opposing balls, a very similar arrangement based on the 'Hirth Face Gear' was patented by A.A. Gage Co., Detroit, Michigan. Hirth gears can be likened to two flattened bevel gears in direct mesh with one another. High precision is achieved in two ways (1) The teeth have an averaging effect when in mesh. (2) The teeth can be lapped in random contact giving greater accuracy. A.A. Gage manufactured a wide range of indexing equipment using the Hirth principle, and together with the extreme accuracy of $\pm 1/4$ second of arc, they should be complimented on their achievements.

The Moore Special Tool Co., Bridgeport, Connecticut who manufacture extremely accurate Jig borers, Jig Grinders and Measuring machines, saw the possibilities of using the gear type indexing system for their machines and took over the manufacturing rights of the A.A. Gage 'Ultradex System'.

I first came across the idea of using a single row of balls and detent pin for indexing at a workshop visit in 1968 organised by Mr D.C. Gall for Members of The Society of Ornamental Turners. Mr D.C. Gall was Managing Director of a very famous company of electrical instrument manufacturers and in 1943 wrote a paper for the Journal of Scientific Instruments entitled Making Accurate Division Plates. In this paper he described his disc type division plate having three grooves for rows of 80, 90, and 100 balls and a chisel pointed pin to engage with the balls and lock the division plate in selected positions.

In conclusion a Mr W.F. Young described in Model Engineer for 3 October 1935 an interesting method of indexing using a single row of balls. The indexing detent is fixed to one of the balls and together are removable from the row of balls. Also two of the balls in the row are fitted with screwed studs, so they can be locked in to retain the position of the row or removed from the row of balls. Indexing is accomplished by removing a ball from the row of balls and then engaging the ball of the indexing indent into the vacated position in the row. It would appear that according to the author that grease was needed to help keep the balls in the groove!

I should be only too pleased to give further details to anyone particularly interested.

Counter-productive adverts?

From George Swallow, Dorking, Surrey.

The results of the Reader Survey were

interesting, particularly the finding that we are all getting older. This being so, could it be used as a justification for your asking your advertisers to use bigger print in their classified adverts? Shouting about their product in six-point is hardly advertising at all.

If the next reader survey shows a widespread intention of getting a microscope as the next important purchase, you know now in advance that we are not defecting to studying pond-life, but stocking up with materials.

More on the Lammas toolpost

From Derek Cooke, Katoomba, New South Wales

With regard to the article by the late and much missed David Lammas in issue No. 27, I was the Antipodean author of the letter praising the tool-post, and to this day, it is one of two or three items in my workshop which immediately rivet the attention of 'proper' engineers. (I'm a self-taught amateur). Recently a chance meeting with a young chap caused me to photostat Dave's original article (M.E. 2 Aug 85), and my letter (3 June 86) to enable him to 'roll his own'. Using the indices for each volume which I file in plastic envelopes, I was soon able, knowing how long after I'd retired I'd bought my 'big' lathe, and roughly how long after that I'd seen Dave's article, to turn up the original. My letter proved rather more difficult to track, as it had not been indexed - probably because it had been headed 'In praise of the Lammas tool-post', rather ignoring the fact that it was also a 'handing on experience' letter. The original article had described making the tri-corn toolpost from a slab of steel for a smallish lathe; a somewhat impractical method in my case. However, within 2 hours of my reading Dave's article, the shellac was drying on a pattern, and a year or two later, I felt I should inform my fellows of my errors. The major one was to make a pattern with the grooves only needing a-finishing cut. I should have made the pattern 'slab-sided' as in the MEW article. This would have saved me making a two-part pattern, and made life easier for the moulder, and the milling (done as in the MEW article), a much more comfortable process using a 1in. end-mill as I did. I also rather regretted not having had a third casting made, so that I could have a left hander. Using a hefty lump of cast iron, I organised the machining of top, bottom and bore so that the workpiece was being either pushed into the 3 jaw SC chuck by a drill, or being pulled in by a draw-bar.

Firstly the work-piece was gripped in the chuck with the bottom facing the tailstock, and drilled about 12mm deep and tapped for the draw-bar. It was then reversed and held into the chuck by the draw bar, the top being then faced and drilled and tapped as before. Again reversed, the bottom was faced, brought to the right height, recessed, drilled as far as the draw-bar end and bored to fit the

thick bottom end of the tool-post stud. The draw-bar was then removed, and the drilling completed. The 1/2in. tools are secured by 3/8in. BSW square-head screws. There is one set of tools for steel (brazed-on carbide tips) and one set for brass (HSS). I still use the 4-seater tool-post for boring tools and for tools which I had made specially for use with it. I also use it with three hefty tool-bit holders (R., L., and straight). These come in useful when there has to be an overhang and also when turning aluminium. Life is too short to be grinding 20deg. rakes on 1/2in.

HSS: it takes quite long enough on 1/4in. bits! Normally there is only one tool in the 4-seater, which brings me to Dave's remark about reducing the risk of injury by 25%. Pre-Lammas, my paws were never without evidence of contact with sharp lathe tools. Post-Lammas, I do not recall having cut a hand on a lathe tool. A 100% reduction. The foundry I mentioned in my letter in M.E. is, alas, no more. My phone number (which was misprinted), does not apply anyway (moved 7 years ago), but if anyone with an LAM 350 BH precision bench lathe, and a shaper is

interested, I still have the pattern, which would be ideal for use with a shaper. Contact via MEW.

One other advantage of the Lammas tool-post which was not mentioned, is that its greater mass and the fact that only the tool nose is showing, must lead to less chatter. If anyone feels that they cannot stop making a model 'just' to make a Lammas toolpost, let them change their mind at once. The time spent will be repaid one hundred fold long before the 'puffer' is finished.



IN OUR NEXT ISSUE

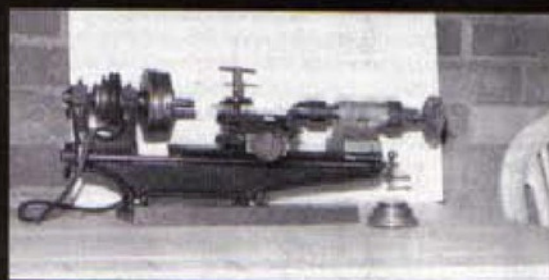
Coming up in the **SEPTEMBER/OCTOBER** issue, No. 27, will be:



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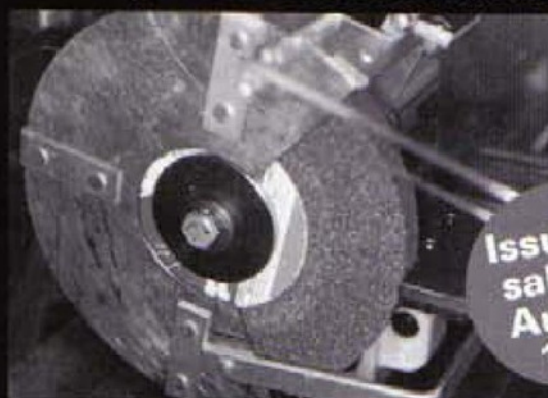
• **A REPLACEMENT TAILSTOCK**
Alan Bourne's small lathe was without a tailstock, so he set out to construct a replacement.

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